

**SALMON  
HABITAT LIMITING FACTORS  
WATER RESOURCE INVENTORY AREA 6  
ISLAND COUNTY**



**WASHINGTON STATE  
CONSERVATION COMMISSION**

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Several maps have been included with this report for your reference. The maps are appended to the report, either as a separate electronic file (for the electronic copy of this report) or separate printed section (for hard copy). The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. Below is a list of maps that are included in the WRIA 6 Maps file:

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## **EXECUTIVE SUMMARY**

This report is an assessment of the habitat factors limiting salmon productivity in the freshwater streams and nearshore saltwater habitats of Water Resource Inventory Area (WRIA) 6. This WRIA overlaps Island County, including Whidbey, Camano, Ben Sur, Smith and Strawberry Islands. Whidbey and Camano, the two largest islands, are the focus of the document. Together they cover about 538 km<sup>2</sup> and include 123 sub-basins.

### **Watershed Description**

The natural characteristics of WRIA 6 are directly affected by human population and land use. Island County is the second smallest but second fastest growing county in Washington State. Between 1980 and 1990, the County's population grew by 37 %, the highest in the state. The 1997 population was 71,600. The incorporated Urban Growth Areas of Oak Harbor, Langley and Coupeville total 12.8 km<sup>2</sup>. Government lands total 42.8 km<sup>2</sup>, including state parks and Whidbey Naval Air Station. Sixty-two percent (329.2 km<sup>2</sup>) of Island County's land is zoned for residential land use. Lands zoned for forest management (44.5 km<sup>2</sup>) and agriculture (18.6 km<sup>2</sup>) comprise 12 % of County land. About 45 % of these parcels have not been developed.

Agriculture has been an important historical land use in WRIA 6, though it is relatively small in comparison to other counties. In 1997, there were 622 parcels (52.8 km<sup>2</sup>) of land in agricultural tax programs. Of this total, 40.2 km<sup>2</sup> were in parcels 0.08 km<sup>2</sup> (20 ac) or larger. In 1987, there were only 4 farms over 2.0 km<sup>2</sup> in size.

Island County considers its housing stock to be its "largest long-term capital asset." Residential development encompasses much of the WRIA 6 shoreline and is expanding into rural and forested areas. The shorelines are in high demand for private beachfront homes and sites with scenic vistas of the water and mountains. The parcels comprising nearly 80 % of the County's shoreline are developed, primarily with platted single-family communities.

### **Distribution and Condition of Stocks**

Virtually no historical information concerning the presence of anadromous salmonids in WRIA 6 was located in the course of preparing this report. Some local residents reported seeing "salmon" or knew of someone that had seen "salmon" in locations where the fish are yet to be documented. A systematic interview of long-time County residents is probably the only way to obtain an historic perspective of fish presence in this area.

What is known is that the islands in WRIA 6 are located at the junction to Puget Sound and in front of some of the most productive salmon-producing rivers (Snohomish, Stillaguamish, Skagit) in western Washington. Historically, this area has served as "one of the most important and critical harvest areas for commercial and sport fisheries." From a regional standpoint, Island County's major contribution to salmon productivity is its

nearshore habitats. The WDFW marine fry nearshore surveys for WRIA 6 are used to forecast the number of adult pink and chum salmon returning to the Snohomish and Stillaguamish Rivers. Juvenile chinook caught for research purposes in the nearshore habitat of north Whidbey Island were assumed to originate from the Skagit River. All species of juvenile salmon use nearshore habitats in Puget Sound at either the fry and/or smolt life stages. Nearshore habitats are also important to migrating adult salmon. The WRIA 6 nearshore environment includes numerous estuaries and salt marshes and provides important habitat for spawning herring and other species that are food for salmonids.

Most WRIA 6 streams are intermittent or ephemeral, and generally do not provide a sufficient flow of water to support salmonids. Others, such as Maxwellton and Glendale Creeks on Whidbey Island, are *presumed* to flow throughout their length year-round and to support small populations of resident and anadromous salmonids. Six sub-basins in WRIA 6 are currently known or presumed to support salmonids. Ten more sub-basins have been identified as having potential to provide salmonid habitat.

The streams in Island County have received little attention from fisheries managers because they are too small to support commercial runs. Accordingly, there has yet to be a systematic survey of existing salmonid habitats and populations. Most of the information documenting fish presence was gathered by WDFW personnel as part of culvert and flow inventories conducted for regulatory purposes (Base 1999).

The 1992 *Washington State Salmon and Steelhead Stock Inventory* (SASSI) identifies only one stock in WRIA 6. Coho are described for the Maxwellton Creek drainage but stock status is unknown. Coho and chum are known to occur in freshwater streams on Whidbey Island. The origin of both stocks is unknown. Coastal cutthroat are present in streams on Whidbey and Camano Islands. A systematic stream survey and genetic analysis of all salmonid species in this WRIA are warranted. The intent of the state legislation that fostered this report is to focus restoration and protection efforts on salmon populations that are “capable of self-sustaining, natural production.”

There has been no systematic survey of salmonid use of nearshore and estuarine habitats in WRIA 6. Data from four state and tribal studies are used in this report to document nearshore habitat use by chum, pink, chinook, coho, sockeye, steelhead and char at several locations in WRIA 6. Twenty estuary/salt marsh sites in WRIA 6 are presumed to support or identified as having potential to support salmonids.

In March 1999, Puget Sound chinook stocks were designated as threatened under the federal Endangered Species Act. There are no streams in WRIA 6 of sufficient size or flow to provide spawning habitat for adult chinook. However, juveniles may use the lower stream reaches for rearing, and they are presumed to use the entire nearshore habitat of WRIA 6. They have been documented along the shoreline at: the north end of Whidbey Island, and the south end of Whidbey and Camano Islands.

In October 1999, bull trout were listed as threatened under the federal Endangered Species Act. Neither bull trout nor Dolly Varden are known to occur in the fresh waters of WRIA 6. Native char are presumed to use nearshore habitat, but only one Dolly Varden is documented in the data sources used in this report. Bulltrout and coastal cutthroat are reportedly caught by sport fishermen in some nearshore areas of WRIA 6.

### **Habitat Limiting Factors**

There are several habitat factors negatively affecting salmon and their habitats in WRIA 6. The major factors are discussed below.

*Streamflow.* Low flows are presumed to be a key habitat factor in this WRIA. However, streamflow data are sorely needed for most of the streams known to support or identified as having the potential to support salmon. The TAG did not have enough information to accurately pinpoint temporal and spatial flow deficiencies or to determine that low flows are not an issue.

The streams in Island County are tiny when compared to the rivers found in other parts of Puget Sound. Most are short, coastal tributaries that flow intermittently due to precipitation patterns, lack of snow accumulation, soil conditions, and topography. They tend to be shallow, have relatively low discharge, and reduced flows during the summer months when precipitation is low. Wetlands and groundwater springs provide the headwaters and baseflows. The perennial streams are predominantly located in the southern part of Whidbey Island, and are fed by year-round springs and forested wetlands. They often have shallow gradients and low velocity. These streams are too small to support habitat for adult chinook salmon, pink salmon, and steelhead.

In Puget Sound, low streamflows are generally most problematic from July through September. The cumulative effect of groundwater withdrawals and loss of wetlands can contribute to low flows. Low flows can cause salmon to be stranded, limit or impede salmon migration, and contribute to a decrease in dissolved oxygen, an increase in water temperature, and an increase in the concentration of pollutants. A cursory analysis of projected effective impervious area suggests that if the County's zoning designations are actualized, impaired and moderately impaired streamflows may be expected in most of the known and potential fish-bearing sub-basins in WRIA 6. Hence, the potential exists for future reductions in streams with naturally low streamflows and for "flashy" streamflows similar to what has happened to many urban streams in Puget Sound.

*Access.* Access is a major habitat factor in WRIA 6. Culverts, tide gates, and dikes are the main structures impeding or preventing fish passage. A few small dams are also present. There are only four sites, identified as being important to salmon, which do not have access issues. Only a limited amount of information was available for two additional sites. They require further investigation.

Low stream flow or temperature conditions can also function as barriers to fish passage during certain times of the year, particularly during the summer. As discussed above, data

are currently lacking to determine if these types of access problems exist at any of the known or potential salmon-bearing sites.

*Flooding and Tidal Flows.* Freshwater and tidal flooding and storm-related flooding are natural processes that are critical to creating and maintaining the health of floodplain and nearshore ecosystems for salmon and other organisms. Flooding occurs generally in the winter in concert with storms, high tides, and seasonally high precipitation. The last large flood event occurred in December 1996. Low-lying areas along the west shoreline of Whidbey Island are most susceptible to flooding from storm surges and high wind-generated waves.

Much of the habitat damage to the salt marshes and estuaries in WRIA 6 has resulted from the loss of connectivity to Puget Sound tidal waters. Agriculture and shoreline residential development has had the biggest impacts on tidal connectivity. In the early 1900s, drainage districts were established in agricultural areas to move water off of the land and allow for development. In more recent decades, numerous residential developments have been constructed on natural or augmented sand spits to raise homes above tidal flood levels, creating a barrier to saltwater flow.

The larger sites that have been impacted by a loss of tidal connectivity include Deer Lagoon, Crockett Lake, Cultus Bay, Swantown Marsh, Maxwellton Estuary, and Crescent Marsh. Copies of historical topographic surveys of the WRIA 6 coastline dating back to the mid-1880s are included in this report, along with recent aerial photos, to give the reader a visual idea of how these sites have been impacted by human land uses. These historic maps may be used in the future to guide restoration efforts.

*Riparian Conditions.* There is currently no quantitative information concerning the riparian zones for streams and estuaries in WRIA 6. Qualitative field assessments have been made in the course of completing this report. Generally speaking, the riparian zones in agricultural and urban areas have been the most heavily degraded, and in some areas, are totally gone.

*Estuary and Nearshore Habitats.* Whidbey and Camano Islands historically supported a number of estuaries and other nearshore ecosystems. As already mentioned, most of these sites have been heavily modified by agricultural, residential and other land uses. Other nearshore sites are still functioning with natural processes but are under private ownership and vulnerable to future disturbance. Loss of access to fish passage, loss of connectivity between streams and tidal waters, and degraded riparian habitat are the main habitat factors.

Shoreline residential homes continue to have a major impact on the nearshore environment. Once the homes are built, property owners often construct bulkheads to protect them from erosion. Bulkheads, docks, groins, and marinas all impact salmon habitat. Water quality impacts occur when septic systems are installed for domestic sewage and experience flooding in relation to naturally fluctuating water levels.

Non-native cordgrasses (*Spartina*) also pose a threat to some WRIA 6 nearshore areas. Cordgrass invasions eliminate native salt marsh vegetation, displace native plants and animals, raise the elevation of the estuary substrate, and lead to an increase in flooding. The primary areas targeted for *Spartina* control are located around the north half of Camano Island. They include Davis Slough, West Pass, Livingston Bay and Triangle Cove. Much smaller infestations occur around Whidbey Island. There, control activities are in place at Cultus Bay, Deer Lagoon, Lake Hancock, and other locations.

*Water Quality.* Nonpoint source pollution is a major cause of water quality pollution in Puget Sound. For salmonids, high water temperature and low dissolved oxygen are the main water quality concerns. High temperatures can lower dissolved oxygen, impair the immune system of salmon, and give non-native warm water species a competitive edge over native salmonids. There are limited water quality data available for known and potential salmon-bearing streams in WRIA 6, but most of the information was gathered at times when temperature and dissolved oxygen conditions would not be expected to be problematic. Additional low flow data are needed for all of the known and potential salmon-bearing streams identified in this report.

### **Habitat In Need of Protection**

Properly functioning habitat is the most cost-effective habitat to protect. The ability to restore degraded habitat back to its proper function is limited by our technical knowledge of the complex interactions associated with the different habitat types. Within WRIA 6, the vast majority of the salmon habitat has been impacted, at some level, by human activities. Habitats in need of protection within the sub-basins and along the coastal shoreline are those areas that still retain a significant portion of their original habitat functions or possess a high potential for restoration.

Lake Hancock is one the best examples in WRIA 6 of a coastal intertidal environment that still resembles the native ecosystem. It is now managed as a protected area by Whidbey NAS and The Nature Conservancy of Washington. In this report, a few other small, coastal wetlands and freshwater streams are identified to be functioning relatively well under natural processes but still existing in private ownership without formal protection. They are located on the east shoreline of Whidbey Island and include Grasser's Lagoon, Harrington Lagoon, and Race Lagoon. Cultus Bay, Triangle Cove, Deer Lagoon, Swantown Marsh, Maxwellton Estuary, and Crockett Lake are much larger nearshore sites that also deserve protection but will require restoration.

Freshwater stream systems that still maintain a low level of development and relatively healthy riparian corridors include Glendale, Cultus, North Bluff, Chapman, and Deer Creeks. All of these streams have barriers to fish access that need to be remedied, and will require some localized riparian and channel restoration, but the existing hydrological condition is still relatively unimpaired and the streamflows are presumed to be perennial and capable of supporting salmonids throughout much of their length.

## **Data Gaps**

Twenty data gaps are identified for the purpose of guiding future inventory and research needs. The data gaps were compiled from the information sources used to prepare this document and with assistance from the WRIA 6 Technical Advisory Group. High priority items are related fish surveys, streamflow data, estuary and nearshore inventories, and physical habitat surveys.

The land use and land ownership conditions in WRIA 6 present several exciting opportunities for beneficial and relatively cost effective salmon habitat restoration opportunities. This is particularly true for the larger estuaries and saltmarshes in the nearshore environment. Feasibility studies for high priority restoration projects are needed now to identify historical conditions, design restoration options, and address social and economic issues.

## INTRODUCTION

This report was written pursuant to the Salmon Recovery Act, passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595 (Revised Code of Washington (RCW) 75.46). It is an assessment of the habitat factors limiting salmon productivity in the freshwater streams and nearshore saltwater habitat of Water Resource Inventory Area (WRIA) 6 (Figure 1). As defined in the law, salmon populations that are “capable of self-sustaining, natural production” are the focus of this analysis.

The study area is located in north Puget Sound and is bounded on the north by Deception Pass, on the east by Skagit Bay, Port Susan and Possession Sound, and on the west by the Strait of Juan de Fuca and Admiralty Inlet. The geographical boundaries of WRIA 6 generally overlap with Island County and include five islands: Whidbey, Camano, Ben Ure, Strawberry and Smith. Whidbey and Camano Islands, the two largest islands, are emphasized in this document.

### **The Habitat Limiting Factors Project**

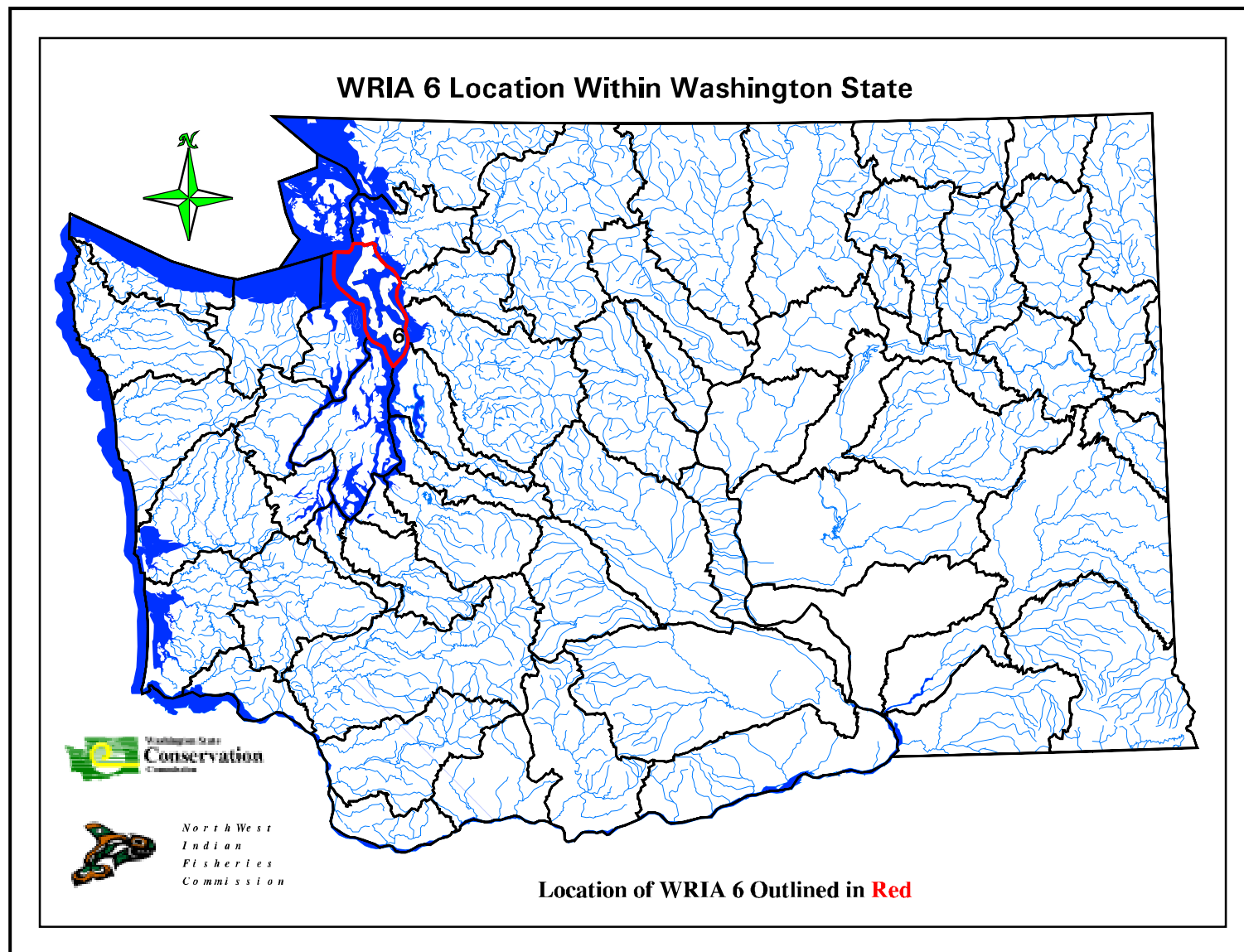
There are two primary purposes of this report: 1) to assist the lead entity's citizen committee with the development of a prioritized list of habitat restoration and protection projects; and 2) to help funding agencies direct limited dollars to the most effective and economical projects. This document may also be used to assist with the development of habitat recovery plans for federally listed threatened and endangered species. This analysis is a compilation and synthesis of the most recent and pertinent sources of existing data and information relevant to the salmonids using the freshwater, estuarine and nearshore environments. It is not, however, an exhaustive assessment of *all* information that is available; that is beyond the scope of work. Readers are encouraged to consult the many scientific sources of information cited herein for more specific information.

The salmonid stocks identified in the *Washington State Salmon and Steelhead Stock Inventory* (SASSI), co-authored by the Washington Department of Fish and Wildlife (WDFW) and the Western Washington Treaty Indian Tribes (WWTIT) (WDFW and WWTIT 1994; WDFW 1998) are the starting point for the limiting factors project. To date, only coho salmon (*Oncorhynchus kisutch*) are listed by SASSI in WRIA 6. Other salmonids have also been documented in some of the freshwater streams. Additionally, the nearshore habitat of Island County provides rearing and migrating habitat for all of the anadromous salmonid species known to inhabit Puget Sound (Fresh 1999). Documentation of nearshore use by several salmonid species exists for many locations.

A Technical Advisory Group (TAG) representing tribal, state, and local resource management agencies provided considerable assistance with the development of this report. Information was also gathered from federal agencies. The TAG's function is to identify the conditions that limit the ability of habitat to fully sustain populations of salmon. Pursuant to RCW 75.46.090, the Washington State Conservation Commission established the TAG in consultation with Island County, the “lead entity” for WRIA 6. Tribal governments with usual and accustomed fishing rights in this WRIA are supporting this project.



Figure 1. WRIA Location



## **THE RELATIVE ROLE OF HABITAT IN HEALTHY POPULATIONS OF NATURAL SPAWNING SALMON**

This section of the report is contained in all of the habitat limiting factors reports now in progress throughout Washington State. It provides a general overview of the freshwater and saltwater life history requirements of the anadromous and resident salmonids in WRIA 6 and other watersheds in Washington. Some of the text has been modified for WRIA 6, while other parts will not apply to the life history stages of the species or habitat conditions found in Island County.

During the last 10,000 years, the Puget Sound anadromous salmonid populations have evolved in their specific habitats. Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of each salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Salmon habitat includes physical, chemical and biological components. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. These components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary and nearshore rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

### **General Freshwater Habitat Needs**

Spawning salmonids not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and in-stream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population,

in addition to the constant need of adequate flows and water quality, all in unison at the necessary location and at the right time. The timing of the freshwater life history phases for the salmonids known to be using streams in WRIA 6 is shown in Table 1. Some of these species may not be part of naturally occurring spawning populations.

Table 1. General timing of freshwater life stages for salmonids in WRIA 6.

Species	Life Phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coho	Upstream migration	-----									-----		
	Spawning	-----									-----		
	Incubation	-----									-----		
	Juvenile rearing	-----									-----		
	Smolt outmigration				-----								
Chum	Upstream migration										-----		
	Spawning	-----									-----		
	Incubation	-----									-----		
	Juvenile rearing			-----									
	Smolt outmigration			-----									
Coastal	Upstream migration							-----					
Cutthroat	Spawning		-----										
	Incubation		-----										
	Juvenile rearing	-----											
	Smolt outmigration				-----								

After spawning, the eggs need stable sediment-free gravel. Stream channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural stream system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water draining into the stream. The natural, healthy stream is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the stream at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is sufficient enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within the stream ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum (*Oncorhynchus keta*), pink (*Oncorhynchus gorbuscha*), and some chinook (*Oncorhynchus tshawytscha*) salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead (*Oncorhynchus mykiss*), bulltrout (*Salvelinus confluentus*), and chinook, search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel areas are vital for early juvenile rearing

habitat. The presence of woody debris and overhead cover contribute food and nutrients and provide protection from predators. Juvenile salmon typically use this type of habitat in the spring. Most juvenile sockeye (*Oncorhynchus nerka*) salmon migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in the lake habitat before migrating to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bulltrout, and certain types of chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, precipitation, connectivity to wetland discharges, and groundwater maintain summer streamflows. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, the juvenile salmon that remain in freshwater begin to move out of the mainstem, and back into quiet off-channel habitat. During the winter, coho, steelhead, bulltrout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead cover are important habitat components during this time of year.

Except for bulltrout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each stream is unique, and has shaped the characteristics of the salmon populations over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

### **General Estuary and Nearshore Habitat Needs**

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Nearshore habitats are also important to the life history of salmonids. They include the intertidal and shallow subtidal marine waters, unvegetated zones, rocky shores, sand- and mudflats, and eelgrass, kelp, and intertidal algal beds (Lynn 1998). All species of juvenile salmon use nearshore habitats in Puget Sound at either the fry and/or smolt life stages (PSWQA 1990; Levings and Thom 1994). Returning adult salmon also use nearshore habitats. Table 2 shows the general timing of nearshore life stages for juvenile salmonids in WRIA 6.

The processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common

disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

### Species-Specific Habitat Needs

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a stream are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Table 2. General timing of nearshore life stages for juvenile salmonids in WRIA 6 shorelines.

Species	Life Phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook	Juvenile rearing				-----								
Coho	Juvenile rearing				-----								
Pink	Juvenile rearing		-----										
Chum	Juvenile rearing		-----										
Sockeye	Juvenile rearing					-----							
Char	Juvenile rearing	-----											
Coastal Cutthroat	Juvenile rearing	-----											

### Pink Salmon

Pink and chum salmon use streams the least amount of time. In Washington, adult pink salmon typically begin to enter the rivers in August and spawn in September and October. During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components such as less frequent and shallower pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel can worsen these flow and water quality problems because there are fewer refuges for the adults to use prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin that supports both even- and odd-year pink salmon stocks.

After emergence, pink salmon fry migrate almost immediately to the estuarine and marine environment (Roni et al. 1999). Most pink salmon will pass directly through the estuary en route to nearshore areas. During their first weeks at sea, pink fry will tend to congregate in tens or hundreds of thousands, often with chum fry of similar age and size, as they move along the shoreline (Heard 1998). Much of their time is spent in shallow

water only a few centimeters deep. In the north Puget Sound baseline survey, juvenile pink salmon were found in the largest numbers in the neritic waters of north Puget Sound from June through August, particularly in the sand/eelgrass and mud/eelgrass habitats (Miller et al. 1977). Outmigrating juvenile pink salmon were observed in gravel habitats in north Puget Sound in early summer (Miller et al. 1977).

### Chum Salmon

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February.

Chum salmon fry emerge from the nests in March and April, and quickly migrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In the mid 1970s north Puget Sound study, juvenile chum were present in the nearshore areas from May through August (Miller et al. 1977). Outmigrating juvenile chum and pink salmon were observed in gravel habitats in north Puget Sound in early summer (Miller et al., 1977). Juvenile chum were also found in sand/eelgrass habitats in early summer, with coho entering the habitat in late summer. Juvenile chum appeared in the gravel habitat in late spring through early fall (Miller et al. 1977). Juvenile chum salmon were mostly encountered in early spring through July (Miller et al. 1977). The migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets.

Both pink and chum salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary and nearshore environments for growth, these habitats are essential.

### Chinook Salmon

Chinook salmon have three major run types in Washington State. Spring chinook are in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks.

Adult summer chinook begin entering rivers in August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March. Downstream migration to the estuaries occurs over a broad time period (January through August). Some juveniles within a few of these stocks remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry leave the freshwater environment quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others migrate to the estuary. Most summer and fall chinook leave freshwater within their first year of life, but a few stocks (including Snohomish summer chinook and Snohomish fall chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook.

Of the two described races of chinook salmon (stream- and ocean-type), ocean-type chinook make more extensive use of estuary habitats (Roni et al. 1999). Chinook salmon fry prefer protected estuarine habitats with low salinity. They move from the edges of marshes during high tide into protected channels and creeks during low tide, and may venture into less protected areas at night (Healy 1980a, 1982; Kjelson et al. 1982; Levings 1982). As the fry grow, they are found in higher salinity waters and use less-protected estuarine habitats before dispersing into strictly marine habitats. Larger chinook fingerlings and smolts (ocean- or stream-type) immediately use deeper-water estuarine habitats upon leaving freshwater (Everest and Chapman 1972; Healy 1991). In the Nanaimo River estuary, stream-type chinook smolts were rarely captured in the inner estuary, but were common in the outer estuary and in other nearshore sampling stations in the vicinity of Nanaimo in June and July, and were rare after July (Healey 1980b). In the Gulf Islands, young chinook were near constant in abundance from May through October, 1976 (Healey 1980a).

### Coho Salmon

The onset of coho salmon spawning is tied to the first significant fall freshet. Coho typically enter freshwater from September to early December, but they have been observed as early as late July and as late as mid-January. They often mill near the mouths of streams and rivers or in lower pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries. If there is an excessive amount of sediment in these tributaries, the eggs may suffocate. Coho salmon fry use shallow, low-velocity areas for freshwater rearing. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access. Pool habitat is important not only for returning adults, but for all stages of freshwater juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in freshwater for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time. The abundance of coho can be limited by the number of suitable territories available. Streams with more structure (such as logs and undercut banks) support more coho, not only because they provide more territories (useable habitat), but they also provide more food and cover.

In the autumn as the temperature decreases, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks. The fall freshets redistribute them, and overwintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods. The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave freshwater a full year after emerging from their gravel nests with the peak outmigration occurring in early May.

Coho use estuaries primarily for interim food while they adjust physiologically to saltwater. In Puget Sound, juvenile coho salmon are believed to rear in estuarine areas for several days to several weeks (Roni et al. 1999). Coho smolts are found in intertidal and pelagic habitats, and prefer deep, marine-influenced areas (Dawley et al. 1986; MacDonald et al. 1987). Large, woody debris is an important component of estuarine habitat for juvenile coho (McMahon and Holtby 1992). In the mid-1970s north Puget Sound study, juvenile coho were found throughout the neritic waters of north Puget Sound from April through October (Miller et al. 1977). Juvenile coho salmon appeared in the gravel habitat in late spring through early fall and in sand/eelgrass habitats in late summer (Miller et al. 1977).

### Sockeye Salmon

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from one to three years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Stillaguamish and Skagit Rivers) while other populations spawn along the beaches of their natal lake (Baker), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide



a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Most of the sockeye from the Baker Lake and Lake Washington populations spend one year in freshwater and then emigrate to estuarine and marine environments as smolts from late April to early June (Gustafson et al. 1997). In the estuarine habitat they are typically found in faster-flowing mid-channel areas and are rarely observed in off-channel areas like marshes and sloughs (Healey 1980a; Levings et al. 1995). The smolts will spend between a few weeks to a few months in the estuarine and nearshore environment before migrating into deeper, offshore waters (Burgner 1991). In the Gulf Islands, British Columbia, juvenile sockeye concentrate along with young pink and chum (Groot and Margolis 1998).

### Steelhead Salmon

Steelhead have one of the more complex life history patterns among Pacific salmonids. In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature. Summer steelhead usually spawn farther upstream than winter stocks and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

### Coastal Cutthroat Trout

Coastal cutthroat trout (*Oncorhynchus clarki clarki*) are the least studied of the seven *Oncorhynchus* species native to the Pacific Northwest (NWFSC 1999). The paucity of quantitative information concerning the distribution, abundance, age structure, and run timing for this fish is mainly a result of the fact that they are not a commercially important species and therefore have not been studied by management agencies. They differ from others in their genus in that they are generally smaller, rarely overwinter at sea, and normally do not make extensive oceanic migrations. Coastal cutthroat are also believed to have the most diverse and complex set of life histories of any Pacific salmonid in terms of size and age at migration, timing of migrations, age at maturity, and frequency of repeat spawning. They are typically found in narrow (0.7 m to 3.0 m) streams with varying channel gradients. The drainage basins are often less than 13 km<sup>2</sup>. When coastal cutthroat are the only salmonid found in a stream, they are more abundant

in pools (Glova 1984). When coho and sculpins coexist in the same stream system, the cutthroat will be more evenly distributed between pool, riffle and glide habitats.

Eggs hatch from 6 to 7 weeks after spawning, with the alevins emerging between March and June. Peak emergence is in mid-April. The juvenile parr will normally stay in the upper tributaries until they are one year old; then they may move more broadly throughout the stream system. Juvenile cutthroat prefer water temperatures around 15 °C.

An individual drainage may contain up to three or more life history forms including migratory and non-migratory individuals that remain in freshwater and anadromous cutthroat that migrate to the sea. There is some evidence to indicate that individual fish may have the ability to change from one life history type to another in response to environmental and ecological change as described below.

Nonmigratory coastal cutthroat include fish generally found in small streams and headwater tributaries near spawning and rearing sites. They typically grow more slowly than the other two life history forms of cutthroat, are smaller when they reach maturity (usually no larger than 150-200 mm long), and normally do not live longer than 2 to 3 years (Nicholas 1978; June 1981).

Freshwater migratory coastal cutthroat include fish that migrate only within freshwater. Within a drainage they may migrate from large to small tributaries to spawn, from a lake to an upstream lake inlet to spawn, or from a lake to the lake outlet to spawn. This type of coastal cutthroat has been best documented in rivers and lakes with physical barriers to anadromous fish, an example being the population upstream of Willamette Falls in the Willamette River, Oregon. Non-anadromous freshwater migratory cutthroat are rare below barriers or in locations with access to anadromous fish.

Saltwater migratory coastal cutthroat (also known as searun cutthroat) migrate as juveniles from freshwater natal areas in late winter and spring to feed in estuarine or nearshore marine habitats in the summer (NWFSC 1999). They will return to freshwater in the winter to feed, find refuge or spawn, and they most commonly return back to saltwater again in the spring. Some anadromous cutthroat may overwinter in saltwater for at least one year (Bernard et al. 1995). Spawning typically begins in December and continues through June, peaking in February (Pauley et al. 1989). Redds are commonly found in the tails of pools in low-gradient streams. Streamflow is normally less than 0.3 m<sup>3</sup>/s in the summer (Johnston 1982). The spawning areas are mostly upstream of spawning sites used by steelhead and coho, but there may be some overlap (Lowry 1965; Edie 1975; Johnston 1982). Anadromous coastal cutthroat normally enter the marine environment after 2 to 4 years in freshwater (Giger 1972; Michael 1980; Fuss 1982), and do not usually spawn before age four. In Washington, migration to seawater may begin as early as March, peak in mid-May, and normally ends by mid-June.

Juvenile migration into estuary habitat may occur in mid- to late spring. Some juveniles will remain in the estuary throughout the summer until the onset of winter freshets in

November, and then return upstream without ever entering the marine environment. Upstream migration will peak during late winter and early spring (Cedarholm and Scarlett 1982; Hartman and Brown 1987; Garrett 1998). Little is known about the estuarine habitat needs of coastal cutthroat, but estuaries are believed to provide important feeding opportunities and overwintering refuge to juveniles and adults (NWFSC 1999).

The anadromous coastal cutthroat typically migrate closer to the shoreline than chinook and coho salmon, and do not cross large bodies of open water (Jones and Seifert 1997; Pearcy 1997). The marine environment is important to this life history type but poorly understood. Nearshore habitat provides opportunities for growth and dispersal to other drainage systems (NWFSC 1999). They may return to freshwater feeding and spawning areas from late June through April. It has been suggested that sexually immature first-year anadromous cutthroat may migrate to non-natal rivers to feed (Johnston 1982).

### Char

Native char, including bulltrout and Dolly Varden stocks are also dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bulltrout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

### **Interactions Between Salmon Species**

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead. Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant, probably the result of occupying the same habitat at the same time (competition). When juvenile coho are present with juvenile coastal cutthroat they will normally dominate the latter and displace cutthroat into less-preferred, lower gradient riffle habitats (Glova 1984). Coastal cutthroat may hybridize with steelhead. These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon

review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

## WATERSHED DESCRIPTION

### Overview of WRIA 6: Island County

WRIA 6 is located in northwest Washington in the northern part of Puget Sound off the coast of Skagit and Snohomish Counties. The boundaries of WRIA 6 overlap the boundaries of Island County that includes five islands: Whidbey, Camano, Ben Ure, Strawberry, and Smith. Whidbey and Camano Islands are emphasized in this report. Together they cover about 538 km<sup>2</sup>.

For the purposes of this report, 123 sub-basins have been delineated within Whidbey Island (83 sub-basins) and Camano Island (40 sub-basins) using 10 meter Digital Elevation Modeling data (Table 3; Map 1; Appendices A-1 and A-2). The drainages range in size from 0.34 km<sup>2</sup> to 31.03 km<sup>2</sup>. The average sub-basin size on Whidbey (5.23 km<sup>2</sup>) is about two times larger than the average sub-basin size on Camano (2.61 km<sup>2</sup>). Generally speaking, the larger sub-basins on each island tend to be more important to known and potential salmonid fish production.

Table 3: Summary of sub-basin area and shoreline length for Whidbey and Camano Islands.

Island	Sub-basins	Area (km <sup>2</sup> )	Area (ha)	Area (mi <sup>2</sup> )	Area (ac)	Shoreline (km)	Shoreline (mi)
Camano	40	104.27	10427.18	40.26	25765.56	84.99	52.82
Whidbey	83	434.07	43407.75	167.59	107260.54	246.37	153.12
<b>Total</b>	123	538.34	53834.93	207.85	133026.10	331.36	205.94
<b>Average</b>	61.5	3.92	391.83	1.52	968.22	2.55	1.58

The delineated sub-basins generally coincide with the sub-basins mapped by Island County for the County's watershed planning process. The amount of existing information for the sub-basins and their natural features varies significantly. The sub-basins overlying federal or state land have been studied in more detail than those overlying private lands unless scientific studies were conducted as part of a permitting process. A general description of the WRIA is provided below, followed by a more detailed description of the sub-basins that have been identified as important to salmonids.

### Nearshore and Estuarine Habitats

Whidbey and Camano Islands collectively have about 331 km of shoreline. The shoreline length per sub-basin ranges from 0.03 km to 19.31 km. Nearshore habitats include the strip of shallow water and land immediately adjacent to the shoreline (Broadhurst 1998). More specifically, nearshore habitats include "intertidal and shallow subtidal marine waters, unvegetated zones, rocky shores, sand- and mudflats, and eelgrass, kelp, and intertidal algal beds" (Lynn 1998). All species of juvenile salmon use nearshore habitats in Puget Sound at either the fry and/or smolt life stages (PSWQA 1990; Levings and

Thom 1994). Returning adult salmon also use nearshore habitats. In a distributional study of nearshore fish use in Puget Sound, chum salmon and coho salmon occurred exclusively in north Puget Sound study sites (Wingert and Miller 1979).

Estuaries occur sporadically along the nearshore of Island County. They provide the habitat for juvenile salmon to make a physiological transition between freshwater and saltwater. They also export nutrients in the form of organic carbon, which are important to the invertebrates upon which salmon feed. Estuaries also support vegetation that helps to shelter salmon from predators (Simenstad et al. 1982). The blind channels found in the saltmarshes of estuaries provide critical rearing habitat for juveniles, particularly chum, chinook and pink salmon (Collins 1997).

The nearshore area of WRIA 6 also provides habitat for spawning herring and other species that are food for salmonids. Herring spawning locations and eelgrass communities are shown in Map 2. Shellfish are also dependent on the nearshore. Three Native American tribal units claim fishing and/or harvesting areas or shellfish gathering rights in WRIA 6. These include the Point No Point, Skagit System Cooperative and Tulalip Tribes. Penn Cove is one of the largest and most important commercial mussel growing and harvesting areas in Washington State. The WDNR has several recreational shellfish beaches. Private beaches are often used for shellfish harvest as well. Shellfish harvest is prohibited in several locations including the City of Oak Harbor, Ault Field, Seaplane Station, Penn Cove Sewer District, and the Town of Coupeville.

Intertidal saltmarshes rank among the most biologically productive ecosystems in the world (Kunze 1984). Numerous saltmarshes, lagoons, tidal flats, and accretion beaches are found along the shoreline of the islands, although virtually all of them have been severely altered by human development as they have throughout Puget Sound. Between the mid-1800s and 1990, 71 % of the tidal marshes were lost in Puget Sound (Thom and Hallum 1991). The losses in Puget Sound and in Island County are primarily associated with agriculture. During early European settlement, the coastal areas of Puget Sound were often the centers of human activities and agriculture was the primary land use. The tidal marshlands were diked, ditched and drained to create arable farmlands and were also used as pasture. Coastal agriculture lands were deliberately isolated from natural tidal and freshwater flooding processes. The result of past and current land and water uses has been the near elimination of pristine coastal wetlands in Puget Sound (Kunze 1984). The coastal saltmarshes and estuaries of Whidbey and Camano islands also suffered. Many of these sites still exist but they are much smaller and highly modified due to human land use changes.

Despite the abundance and importance of its nearshore habitat, WRIA 6 lacks a systematic nearshore inventory.

### Geology and Topography

The topographic relief of Whidbey and Camano Islands ranges from between 61 m to 122 m above sea level (KCM 1998). The steepest slopes are found at the south end of

Whidbey Island. Here many areas have slopes exceeding 15 %, and there are some near-vertical bluffs. The island topography was predominantly shaped by the Puget Lobe of the Cordilleran ice sheet. This ice sheet formed during the Pleistocene Epoch between 2.2 million and 10,000 years ago. Continental glaciers advanced (and retreated) from Canada into Puget Sound during this time. The last period of glacial advance, known as the Vashon Stade of the Fraser Glaciation, reached its maximum between 18,000 and 14,000 years ago (Burns 1985). About 1,250 m of ice covered the area near Whidbey Island during that time. An unsorted layer of boulders and clay, referred to as the Vashon Till, was left behind and now covers most of the upland areas. The till is from 1 m to 53 m thick (Easterbrook 1968).

### Soils

The relatively thin layer of soils found in WRIA 6 developed under the influence of a moist marine climate, and resemble soils found in other areas of the Puget Sound basin (USDA 1958). Most developed under forest vegetation. The Island County soils have been classified into six categories by the Soil Conservation Service (now the National Resources Conservation Service) according to the formation processes and geologic features with which they are associated. The soils of the glacial uplands, Hoypus, Keystone, Whidbey, Swantown, Casey, Townsend, and Bozarth soil series, cover about 75 % of the land area. The Everett, Indianola, Alderwood, and Bow soils also fall into this category; they occur on Camano Island. The soils of the terraces occupy about 3 % of the land area, and are the most important agricultural soils. They include the Pondilla, San Juan, Snakelum, Ebeys, and Coupeville series.

The NRCS-identified hydric soils are used in this report to help identify historic wetland sites along streams and in coastal areas (Map 3). A hydric soil is a soil that, in its undrained condition, is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation (Hydrophytes). The use of hydric soils and other criteria to map historic wetlands has been used by the Washington Department of Ecology to map historic wetlands in the Stillaguamish and Nooksack drainages (Gersib 1997).

Soils associated with topographic depressions, deltas, and tidal flats are hydric. The Norma, Bellingham, and Coveland series are found in topographic depressions in uplands and terraces. These soils receive considerable seepage and runoff from surrounding land. All are saturated during the wet season and they are often under water, unless they have been drained. About 2 % of the land area in Island County is occupied by soils of deltas and tidal flats. They include the Hovde, Lummi, and Puget series. The Hovde sand is found in coastal beach areas with 0 % to 2 % slope. The Lummi soils occupied low deltas next to tidal marshes or marine waters. These soils were generally salty before being diked, drained and reclaimed. The Puget Soils occupy river deltas. Organic soils are composed mainly of plant materials in various stages of decomposition. They are found in shallow lakes or permanently wet depressions. The organic soils include Carbondale muck, Greenwood peat, Mukilteo peat, Rifle peat, Semiahmoo muck, and Tacoma peat.

## Climate and Hydrology

WRIA 6 has a relatively uniform maritime climate characterized by moist, mild winters and cool dry summers. The Cascade Mountains shelter the islands from cold continental winds. The prevailing wind direction is from the south and southwest in the fall and winter, and from the west and northwest in the spring and summer. The islands lie in the rain shadow of the Olympic Mountains to the southwest, and so part of the islands receive less average annual precipitation (53 cm) at Coupeville than in Seattle (96 cm), or Everett and Bellingham (91 cm) (EA Engineering 1996). The southern part of Whidbey Island, however, averages about 89 cm annually. About 80 % of the annual precipitation occurs from October through May. The mean daily temperature on Whidbey is 10 °C. Snow is rare.

The streams in WRIA 6 are very small when compared to the rivers found in other parts of north Puget Sound (Stillaguamish, Skagit, and Nooksack). Most island streams are short, coastal tributaries that flow intermittently due to precipitation patterns, lack of snow accumulation, soil conditions and topography. They tend to be shallow and have reduced flows during the summer months when precipitation is low. Surface runoff is estimated to range from 0 % to 7 % of precipitation (KCM 1998). The perennial streams are predominantly located in the southern part of Whidbey Island, and are fed by year-round springs. They often have shallow gradients and low velocity (EA Engineering 1996). Streamflow data are sorely lacking in this WRIA. A stream gage was installed in Cultus Creek in 1997 by Island County and the US Geological Survey to collect data for a groundwater recharge study. Some streamflow data are also available for Maxwellton Creek. The data were collected by a local resident between November 1998 and December 1999. Isolated flow measurements were located for a few other streams.

*Flooding.* Flooding occurs generally in the winter in concert with storms, high tides, and seasonally high precipitation. The last large flood event occurred in December 1996. Low-lying areas along the west shoreline of Whidbey Island are most susceptible to flooding from storm surges and high wind-generated waves (FEMA 1995). This is partially a result of the relatively long fetch faced by the western coastline. In some areas, efforts to reclaim tidelands through levying have created back flooding problems as fresh water runoff of upland areas meets high incoming tides.

Several of the stream systems and saltmarshes that are discussed in this report have been identified as areas of frequent flooding or ponding. These include the Swantown drainage basin, Crescent Creek at Fakkema Road, Crockett Lake, North Bluff Creek at North Bluff Road, Maxwellton Creek, Glendale Creek at Glendale Road, Deer Creek at Columbia Beach Road, Chapman Creek at Chapman Road (KCM 1998). A number of drainage basin studies have been prepared for Island County, municipalities, and private landowners (KCM 1998). Tidal flooding and storm-related flooding are natural processes in the lowland marsh areas along the coastlines, and are critical to creating and maintaining the health of these ecosystems for fish and other organisms.



*Lakes.* Thirty-seven lakes, lagoons and large ponds have been identified in Island County, totaling 393 ha of water and 168 ha of associated marshland (Kearsley 1998). There are up to four times more areas containing intermittently ponded waters. The fresh water lakes include Cranberry Lake, Silver Lake, Goss Lake, Lone Lake, Deer Lake, Miller Lake, Oliver Lake, Chase Lake, Honeymoon Lake, Lake Pondilla. Several of the lakes form the headwaters of the streams that are known to support salmonids. These include Miller Lake (Maxwelton Creek), Deer Lake (Deer Creek), and Chapman Lake (Chapman Creek). Seven “lakes” are influenced by tidal fluctuations.

*Wetlands.* Wetlands are critical to a properly functioning watershed. They provide several functions that directly affect salmonids: sediment storage, flood flow storage and desynchronization, temperature maintenance, nutrient removal and transformation, groundwater recharge, and refuge and rearing habitats. Most of the wetlands in WRIA 6 formed in depressions in glacial uplands (Sheldon and Associates 1999c). Some are located at the site of former glacial lakes. A number occur in the deltas and tidal flats along the coastlines. This report focuses on the freshwater and saltwater wetlands that play a role in providing salmonid habitat. Several of the larger sites are included as part of the Island County Public Works Wetland Compensation Program (Sheldon and Associates 1999c).

An estimated 44.6 km<sup>2</sup> of existing wetlands have been identified and mapped in Island County (Map 3). As discussed above, historic wetland area was estimated to be 64 km<sup>2</sup> based on the aerial extent of hydric soils as depicted in the WDNR soils map. A mid-1880s Puget Sound survey of tidal marshes, swamps and dikes identified 16.2 km<sup>2</sup> of tidelands and 9.6 km of dikes in Island County (Nesbit 1885). An early 1980s, study of Puget Sound estuarine wetland areas identified Island County as having 33.9 km<sup>2</sup> of beaches (including tidal flats, rocky shores and other beach substrata), 3.0 km<sup>2</sup> of emergent marsh, .004 km<sup>2</sup> of scrub/shrub, .07 km<sup>2</sup> of forested wetland, and 26.2 km<sup>2</sup> of aquatic beds, totaling about 63 km<sup>2</sup> (Boule’ et al. 1983).

*Beaver Ponds.* Beaver ponds may provide important rearing habitat for coho and other juvenile salmonids (Pollock and Pess 1998). In the Stillaguamish watershed, beaver ponds are used for summer rearing and for overwintering, with the latter use believed to be particularly important. Stream systems with extensive beaver ponds and wetlands, accessible to coho, had significantly higher smolt yields than other systems in the Stillaguamish watershed (Nelson et al. 1997). In WRIA 6, beavers are active in the Maxwelton sub-basin, and have constructed numerous dams.

There is little information currently available on the historic or current beaver population in Island County or on their relationship to salmonids. Beaver pond habitat within the anadromous zone of the Stillaguamish watershed has been reduced by 81 % to 96 % from historic levels (Pollock and Pess 1998). Much of the prime beaver habitat there has been lost as a result of conversion to agricultural cropland, residential housing, and trapping (Pollock and Pess 1998).

*Groundwater.* Groundwater is an important contribution to the quantity and quality of streamflow in WRIA 6 streams. Ground water generally flows along a course that parallels the land surface gradient towards streams and lowlands. Groundwater and surface water flows are inextricably linked, particularly in the summer months, when precipitation is relatively low. Groundwater discharge to streams plays a particularly important role in maintaining streamflows for salmon at these times.

Five major aquifers have been identified on Whidbey Island (Jones 1985). These aquifers are found in unconsolidated sand and gravel deposits that formed during glacial and interglacial conditions. The aquifers are recharged by infiltration from precipitation; about 6 % of the precipitation contributes to recharge (Reid, Middleton and Associates 1988). Groundwater, springs and cisterns supply most human (domestic and livestock) water needs. Private wells serve as the domestic water supply for most Island County residents living in unincorporated areas (Kearsley 1998). Island County and the US Geological Survey are currently researching the groundwater recharge characteristics of the islands. No information was located regarding the impact that groundwater development may have on streamflow in fish-bearing streams.

*Water Quality.* Water quality is critical to protecting the various life stages of salmonids and other organisms in aquatic ecosystems. The low gradient and low velocity of a typical WRIA 6 stream make it prone to sediment deposition, especially in developing areas. Water quality impacts associated with low stream flows, such as elevated water temperature and low dissolved oxygen, can result. Streams are particularly sensitive to these conditions during the summer when precipitation is low and temperatures are high. Loss of riparian (streamside) vegetation can also contribute to high temperatures and low dissolved oxygen. The optimal temperature range for salmon is 12-14 °C, with lower temperatures preferred for spawning. Lethal temperature levels for adults are in the range of 20-25 °C. Salmon eggs show moderate impairment at dissolved oxygen levels of 8 mg/l while adult salmon are moderately impaired at 5 mg/l.

The water quality data located for this report were mostly gathered by Island County for the baseline water quality monitoring program, and by the WDOE for the ambient water quality monitoring program. In Island County, there are two marine areas that are candidates for the State's 303(d) list for problems associated with low dissolved oxygen and high fecal coliform bacteria (Map 4). As defined by the CWA, a water body listed on the state's 303(d) list is not expected to attain water quality standards after implementation of technology-based pollution controls. Typical control measures include discharge permits for point sources and best management practices for nonpoint sources.

*Impaired Streamflow and Impervious Surfaces.* High stream flows can be detrimental to salmon when they cause scouring to occur in gravel beds containing salmon eggs. High flows can also flush large woody debris out of stream channels. Impervious surface is a term commonly used by hydrologists to refer to hard surfaces (such as roads, rooftops, and parking lots) that shed rather than absorb precipitation. Urban areas, clear-cuts, and hardened turf areas produce conditions that impede the land's ability to soak up

rainwater. When this occurs, the increased volume of stormwater runoff often leads to more severe and more frequent flooding, which can negatively impact salmon. When impervious surfaces replace wetlands, groundwater recharge is impacted; streams may lose the base flows that are especially critical to salmon during the summer months.

In urban King County, alterations in streamflow begin to appear when a drainage has as little as 3 % impervious surface (Booth and Jackson 1997). Between 3 % and 10 %, a drainage will likely experience moderate hydrologic impairment, while impaired hydrologic conditions are likely to occur when more than 10 % of a sub-basin is covered by impervious surface (Skagit Watershed Council 1999).

When current land use maps or remote sensing data are available to calculate effective impervious area (EIA), the hydrological condition of a watershed may be evaluated using these thresholds. Another option (which is used in this report) is to use the current zoning coverage to estimate future EIA under the projected build-out conditions. This zoning information was gathered from the Island County Comprehensive Plan (Island County 1998). Because Island County has not developed EIA estimates to correlate with its zoning designations, the numbers used to correlate between the EIA and local zoning were taken from EIA estimates developed by other counties (Snohomish, Skagit and Whatcom) in northwest Washington (Table 4). The table also shows the total area of land in Island County that corresponds with each zoning designation.

Table 4. Estimated effective impervious area for Island County zoning designations.

<b>Proposed Future Land Uses</b>	<b>Area (ac)</b>	<b>Hectare (ha)</b>	<b>EIA %</b>	<b>Source</b>
<b>Rural Lands</b>				
Airport	280	113	86	nd
Light Manufacturing	120	49	48	Snohomish County
Rural Center	560	227	48	Snohomish County
Rural Village	225	91	24	Skagit County
Rural Service	25	10	10	Skagit County
Rural Residential	10,240	4,144	10	Whatcom County
Rural	79,920	32,343	3	Skagit County
Rural Forest	14,000	5,666	2	Whatcom County
Rural Agriculture	8,715	3,527	2	Whatcom County
Commercial Agriculture	1,900	769	2	Whatcom County
Special Review District*	150	61	2	Assumed to be "Agriculture"
Parks	4,160	1,684	2	Whatcom County
Federal Lands	7,880	3,189	nd	nd
<b>Total Rural</b>	128,175	51,872		
<b>Urban Lands</b>				
Municipal Urban Growth Areas	5,825	2,357	86	Snohomish County
<b>Total Area</b>	134,000	106,101		

The EIA has been averaged for each sub-basin to graphically depict future hydrological conditions as shown in Map 5. The EIA for sub-basins containing federal lands (such as

Whidbey NAS) includes only the average EIA for non-federal lands, as federal lands were not designated in the County zoning map. The reader should be further cautioned that Map 5 is based on EIA estimates developed in other watersheds, and that a more accurate future scenario would be based on EIA estimates developed specifically for Island County.

This generalized analysis suggests that if the current zoning designations are actualized, impaired and moderately impaired hydrological conditions may be expected in most of the known and potential fish-bearing sub-basins discussed in this report. This level of development could cause reductions in streamflow and “flashy” streamflows similar to what has happened in many of the urban streams in Puget Sound.

### Vegetation and Riparian Habitat

WRIA 6 lies within the Western Hemlock Zone (Franklin and Dyrness 1973). The mature climax forest of this region consists of western hemlock (*Tsuga heterophylla*) and Western red cedar (*Thuja plicata*). Douglas fir (*Pseudotsuga menziesii*) and madrone (*Arbutus menziesii*) dominate the sub-climax forests. The forests were once mixed Douglas fir, western hemlock and western red cedar trees. Many of the trees from the virgin forests were up to six feet in diameter. Most of these trees have been logged or burned. Second or third growth Douglas fir, mixed red alder (*Alnus rubra*) and thick underbrush now dominate the remaining forested areas. Other common trees and shrubs include Garry oak (*Quercus garryana*), salmonberry (*Rubus spectabilis*) rhododendron (*Rhododendron macrophyllum*), Oregon grape (*Berberis nervosa*), huckleberry (*Vaccinium parvifolium*), and salal (*Gaultheria shallon*).

*Riparian Zone.* Healthy stream and wetland ecosystems are generally bordered by mature trees and other types of vegetation. This riparian zone consists of the transitional ecosystem between aquatic habitats (stream, lake, wetland, estuary) and upland habitats. The riparian area supports vegetation that may be influenced by fluctuating water tables. With respect to salmon, the primary ecological functions of the riparian zone are to provide large woody debris and shade to streams and wetlands, including estuaries. The large woody debris influences the hydrology of the stream channel, which in turn affects habitat types and quality. Shade is important to keeping water temperatures cool, and regulating sunlight and photosynthesis. Riparian vegetation also provides leaf material and other fine organic matter to the aquatic system that serves as food and nutrients for many organisms. The large trees lining stream channels provide structural support to the streambanks that helps to control sediment from entering the water.

In the Pacific Northwest, the ecological integrity of a streamside riparian zone is managed through the maintenance of riparian buffers. There is discrepancy between resource management agencies about the buffer width to maintain ecological functions. For fish-bearing streams, the recommended buffer width ranges from 7.6 m to 30.5 m (WDNR), to 30.5 m to 45.7 m (WDFW), to 91.4 m (USFS) (Pollock 1998). Nonfish-bearing streams typically receive protection for smaller buffers or no buffer at all.

However, these streams, from a watershed perspective are also critical to the overall health of the watershed and the organisms it supports.

There is currently no quantitative information concerning the riparian zones for streams and estuaries in WRIA 6. Qualitative field assessments have been made in the course of completing this report. Generally speaking, the riparian zones in agricultural and urban areas have been the most heavily degraded, and in some areas, are totally gone.

### Population

The natural characteristics of a watershed are directly affected by human presence and land use. Island County is the second smallest but second fastest growing county in Washington State (Kearsley and Hossley 1995). Between 1980 and 1990, the County's population grew by 37 %, the highest in the state. The 1990 population was 60,195 (Kearsley and Hossley 1995) and 71,600 in 1997 (Kearsley 1998). Growth is expected to continue by approximately 7 % per year in both permanent and seasonal population groups. The projected population growth for the four sub-regions of the County is shown in Figure 2.

An estimated 48,710 people live in unincorporated areas, while the remaining 22,890 people live in cities and towns. Oak Harbor is the largest city, accounting for 20,190 individuals. The Town of Coupeville (1,610 people) and the City of Langley (1,090 people) are much smaller. There are no incorporated areas on Camano Island. The unincorporated areas of Clinton and Freeland account for 1,564 and 1,278 people, respectively.

### Land Use

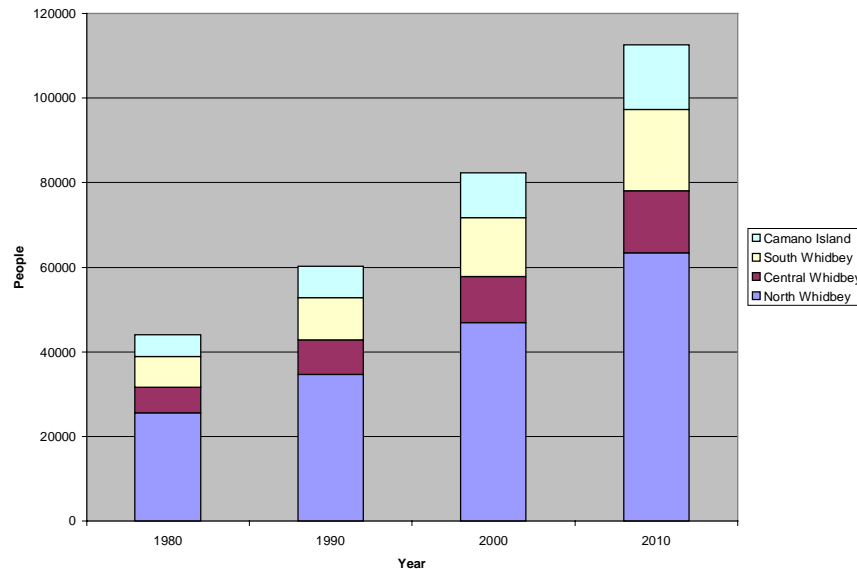
The incorporated Urban Growth Areas of Oak Harbor, Langley and Coupeville total 12.8 km<sup>2</sup>. Government lands total 42.8 km<sup>2</sup>, including state parks and Whidbey Naval Air Station. Thirty-eight percent of the land in Island County is zoned for rural residential land use, totaling 197.2 km<sup>2</sup> (Map 6). Sixty-two percent (329.2 km<sup>2</sup>) of Island County's land is zoned for residential land use. Lands zoned for forest management (44.5 km<sup>2</sup>) and agriculture (18.6 km<sup>2</sup>) comprise 12 % of all County land. Commercial and industrial zoned land account for 1 % of County land, totaling 4.6 km<sup>2</sup>. About 45 % of these parcels have not been developed.

*Residential.* Island County considers its housing stock to be its "largest long-term capital asset" (Island County Department of Planning and Community Development 1998). Residential development encompasses much of the WRIA 6 shoreline and is expanding into rural and forested areas. Residential development in the sub-basins known to support salmonids may pose hydrologic and water quality impacts to the stream systems.

The shorelines are in high demand for private beachfront homes and sites with scenic vistas of the water and mountains. The parcels comprising nearly 80 % of the County's shoreline are developed, primarily with platted single-family communities (Island County

Department of Planning and Community Development 1998). Current shoreline density ranges from 3 to 5 units per acre to 1 unit per 5 and 20 acres. The average density in platted sites is about 2 units per acre. Shoreline development is regulated by the County's Shoreline Master Program.

Figure 2. Projected population growth in Island County sub-regions, 1990-2010 (Kearsley and Hossley 1995).



Shoreline residential development has had one of the biggest impacts on the saltmarshes, estuaries, and nearshore habitats. Numerous residential developments have been constructed on sand spits that separate the Sound from saltmarshes. The spits have often been augmented to raise the homes above tidal flood levels. Once the homes are built, property owners often construct bulkheads along the shoreline in front of the homes to protect them from erosion. Beach structures such as bulkheads prevent the recruitment of coarse and fine sediments to the beach. Docks and groins can prevent the longshore movement of sediment. This can cause the remaining beach to become very coarse as the finer sediments are removed with no replenishment. Removal of the finer sediments will alter the habitat that the beach provides for salmonids and forage fish. Additional impacts to salmonid ecosystems may occur when septic systems are installed for domestic sewage. Concerns about water quality and septic failures often arise in relation to naturally fluctuating water levels in the saltmarshes. The Island County Beachwatchers are in the process of gathering and mapping data on development impacts to the nearshore environment but this data was not available in time for use in this report.

*Agriculture.* Agriculture has been an important historical land use in WRIA 6, though it is relatively small in comparison to other counties. In 1997, there were 622 parcels (52.8 km<sup>2</sup>) of land in agricultural tax programs, although not all of this land is actively farmed (Island County Department of Planning and Community Development 1998). Of this total, 40.2 km<sup>2</sup> were in parcels .08 km<sup>2</sup> (20 ac) or larger. In 1987, there were only 4 farms

over 2.0 km<sup>2</sup> in size. Most of the larger farms have diversified their holdings. Smaller farms, less than .04 km<sup>2</sup> (10 ac) in size, are scattered throughout the County, and are located within residential areas and in agricultural areas. The predominant crops grown are for seed, berries and fruit, and feed (silage, hay and alfalfa). There are also a few livestock operations, including dairies, beef ranches, and poultry and swine farms.

Historic and active drainage and diking districts are associated with most of the larger agricultural areas. Diking districts construct and maintain dikes, levees and associated structures, such as tidegates and pumps. Drainage districts provide drainage facilities.

In the early 1900s, drainage districts were established to move water off of the land and allow for agricultural development. Drainage concerns were primarily handled by reclaiming estuaries, saltmarshes and other wet areas for agricultural purposes and draining areas subject to seasonal inundation. There are several active and inactive diking districts and drainage districts in Island County (Kearsley 1998). Some of these special districts overlay estuary and saltmarsh habitats discussed in this report including Deer Lagoon, Maxwelton Estuary, Swantown Marsh, and Dugualla Estuary. A District must be officially dissolved to be declared inactive.

*Forest Lands.* WRIA 6 contains approximately 64.8 km<sup>2</sup> of private and state-owned forest lands. There are few industrial forest holdings left in Island County. Trillium, Plum Creek and Crown Pacific are the primary commercial timber land owners (Island County Department of Planning and Community Development 1998). The WDNR owns approximately 7.7 km<sup>2</sup> of trust land in Island County (Island County Department of Planning and Community Development 1998). The remaining forest landowners are non-industrial private forest owners. In 1998, about 57 km<sup>2</sup> of private land were managed for timber production (Island County Department of Planning and Community Development 1998). Only a few areas are zoned for commercial forest production. A large percentage of the existing forested land exists in small parcels often associated with farmland or residential development. The larger forest reserves are owned by State Parks or are federal reserve areas, and include Deception Pass State Park (7.4 km<sup>2</sup>), Joseph Whidbey State Park (.45 km<sup>2</sup>), Fort Ebey State Park (2.6 km<sup>2</sup>), Dugualla Bay reserve (2.3 km<sup>2</sup>). Most of the logging that is occurring is associated with land conversion for residential development.

*Commercial and Industrial.* The key commercial areas on Whidbey Island are mainly located along State Route 20 from north of Oak Harbor to Coupeville. Oak Harbor is the County's largest urbanizing area. Industrial activity is limited in WRIA 6. In north Whidbey the industry is mainly associated with non-polluting electronic industries. Industrial businesses are encouraged to locate in designated industrial parks.

*Marinas, Piers and Floats.* Whidbey Island has three public marinas and five additional facilities for day moorage (Kearsley 1998). The public marinas include the Oak Harbor Marina, Langley Marina, and the Port of South Whidbey in Clinton. There are also many privately owned moorage facilities. The Whidbey NAS also operates a marina for military personnel.

## Whidbey Island and Sub-basins

Whidbey Island is the largest island in Puget Sound and in the contiguous United States. It is bounded by Skagit Bay and Deception Pass (north), Admiralty Inlet (west), Possession Sound (south), and Saratoga Passage (east). Whidbey is about 104 km long, from 1.6 km to 16 km wide, encompasses 437 km<sup>2</sup>, and includes 249 km of shoreline. Elevation ranges from sea level to 162 m. The topography of the island is characterized by gentle to moderate slopes at low elevations. Gentle ridges span the length of the island. Most of the island is traversed by lowland valleys below 30 m. Coastal bluffs may be over 61 m high, and are found in places like Ebey's Landing, Pratt's Bluff, Useless Bluff, Scatchet Head, Double Bluff, and Possession Point.

Eighty-three sub-basins have been delineated with the boundaries of Whidbey Island. The largest sub-basins (Maxwelton, Crescent, Useless, Crockett, Dugualla and Swantown) tend to be the most important for salmonid production. (Map 1; Appendices A-1 and A-2). All of these sub-basins have a stream system connected to an estuary. This section of the report describes the sub-basins on Whidbey Island deemed most important for salmon. The number that follows each sub-basin refers to the number assigned on Map 1.

The WDNR has mapped 31 km of Type 2 and 3 Waters on Whidbey Island. Type 1, 2 and 3 Waters have been administratively defined by the State Forest Practice Rules to contain anadromous and resident fish (WAC 222-16-030) (Table 5). The coastal shoreline of Whidbey Island is considered a Type 1 Water and is also defined as a "shoreline of the state."

Table 5. WDNR Water Types.

Water Type	Definition
1	Waters inventoried as "shorelines of the state"
2	Not classified as Type 1; used by "substantial numbers" of anadromous/resident fish
3	Not classified as Type 1 or 2; used by "significant numbers" of anadromous/resident fish
4	Not classified as Type 1, 2 or 3; protects downstream water quality; channel width more than 2 ft
5	Not classified as Type 1, 2, 3 or 4; streams with or without well-defined channels, seeps, ponds
9	Water type unknown/unclassified



### Berry (54)

The 3.0 km<sup>2</sup> Berry Sub-basin is located on the east side of central Whidbey Island just north of Holmes Harbor, and drains east to Saratoga Passage (Map 1). There is 0.9 km of shoreline. Land use is zoned predominantly rural (52 %), forest (32 %), and agricultural (16%) (Map 6). This sub-basin is noted in this report for the wetland habitat that is located between North Bluff Road (east), Shoreline Drive (north) and Greenbank Farm (west). It is owned by Greenbank Beach and Boat Club, the Holmes Harbor Estates (tide gate and lower wetlands), and the Port of Coupeville (upper wetlands near Wonn Road) (Wahlin 2000). Several private homes are located between Saratoga Passage and North Bluff Road, and are prone to occasional flooding (Kearsley 1999).

A topographic map from the late 1880s, indicates that this wetland was linked directly to saltwater (Department of Commerce 1887) (Appendix A-3). It historically functioned as a saltmarsh but today is dominated primarily by freshwater emergent species like cattail (*Typha latifolia*) and *Scirpus tabermontanii* (Sheldon and Associates 1999c). Freshwater enters the wetland from surface runoff. The northeast end of the wetland include mixed emergents: silverweed (*Potentilla anserina*), soft rush (*Juncus effusus*), and climbing nightshade (*Solanum dulcamara*). The northwest edge of the wetland is dominated by shrubs including, clustered rose (*Rosa pisocarpa*), Pacific crabapple (*Malus fusca*), and willow (*Salix sp.*). The southwest buffer of this wetland was enhanced by WSDOT in 1998 as part of a compensation project for offsite wetland impacts (Sheldon and Associates 1999c). Purple loosestrife (*Lythrum salicaria*) is one invasive exotic species reported to be present at this site (Wahlin 2000).

### Crescent (11)

The 30.7 km<sup>2</sup> Crescent Sub-basin is located in the northeast corner of Whidbey Island (Map 1). It is the second largest sub-basin in WRIA 6 and on Whidbey Island. The 19.3-km of shoreline bordering Crescent Harbor, is the longest shoreline length of any sub-basin in Island County. Land use in this drainage is principally associated with Navy personnel support facilities and housing (KCM 1998). The U. S. Naval Reservation occupies most of the sub-basin south of Crescent Harbor Road. About 35 % (10,742 km<sup>2</sup>) of the sub-basin is mapped as federal land by Island County, the other significant zoning designations being rural (53 %) and agricultural (8 %). Rainfall is about 51 cm to 63 cm per year.

Crescent Creek drains this sub-basin from its headwaters in the vicinity of Fakkema Road south to Crescent Marsh and then Crescent Harbor. The WDNR has not mapped any Type 2 or 3 Waters in this sub-basin, however anecdotal information dating back to the 1970s suggest that “salmon” were historically present in the stream and the marsh.

A topographic map dating back to 1888 shows a large wetland adjoining the shoreline of Crescent Harbor in the present location of Crescent Marsh (Appendix A-4) (Department of Commerce 1888). Island County maps indicate that there are about 3.7 km<sup>2</sup> of wetlands in this sub-basin (Map 3). Crescent Marsh is estimated to occupy about .61 km<sup>2</sup> (EA Engineering 1996). The marsh is located between Crescent Harbor Road (north), Torpedo Road (west), and Beach Road (south). All of the wetland is owned and managed by Whidbey NAS. Hunting is allowed in the wetland.

Drainage District 3 was formed in the vicinity of Crescent Marsh in 1919, and has since dissolved (Kearsley and Hossley 1995). The estuary was diked and ditched in the 1930s (Sheldon and Associates 1999c) (Map7). The tributaries draining the marsh were levied and drained for agricultural purposes. Salt water inflows were curtailed by the levy before the 1940s on which East Pioneer Way is now located. The tide gate that was installed in the levy was only opened to minimize wave and tidal surge activity. In 1994, the main tide gate was permanently opened to re-establish salt water flows into the marsh. Saltmarsh plants are reestablishing slowly in the lower portions of the marsh near the tide gate. The main ditch running from tide gate is deep and has high levees on each side, impeding saltwater dispersal into the wetland.

The marsh vegetation is dominated by Halberd-leaf saltbush (*Atriplex patula*), Virginia glasswort (*Salicornia virginica*), seashore saltgrass (*Distichlis spicata*), and Olney's bulrush (*Scirpus americanus*). Cattail and reed canarygrass (*Phalaris arundinacea*) dominate the freshwater portion of the wetland to the east (Sheldon and Associates 1999c). Part of this marsh has been diked for use as a sewage disposal pond and pump station by the City of Oak Harbor. Wastewater effluent from this facility discharges into Crescent Harbor.

The nearshore habitat of Crescent Harbor supports eelgrass and kelp beds, and spawning habitat for surf smelt and Pacific herring (Map 2).

### Crockett (31)

The fourth largest sub-basin in WRIA 6, Crockett is located on the west shoreline of central Whidbey Island about 5 km south of Coupeville (Map 1). The 23 km<sup>2</sup> sub-basin drains south into Crockett Lake and then Admiralty Bay. It has 3.6 km of shoreline. The WDNR has mapped 0.3 km of Type 2-3 Waters. About 60 % (14,027 km<sup>2</sup>) of the land is zoned for rural use, followed by agriculture (19 %) (Map 6). Federal land occupies about 2,641 km<sup>2</sup>. The land ownership in this area includes Fort Casey, Seattle Pacific University Campus, Island County, Washington State Parks and the Town of Coupeville. There are several residential developments including Crockett Lake Estates, Admirals' Cove, and Telaker Shores. Keystone Harbor, a dredged mooring basin at the southwest corner of the harbor, is connected to Admiralty Bay by a 46-m navigation channel (FEMA 1995). A breakwater protects this channel. The Keystone Harbor serves as a refuge, boat launching area, and a terminal for the WSDOT ferries operating between Port Townsend and Keystone. The State ferry terminal was first established near the east end of the lake, and then relocated to Keystone Harbor (Sheldon and Associates 1999a). Approximately 500,000 people annually visit the Fort Casey/Crockett Lake area (FEMA 1995). There are 4.8 km of lake shoreline extending eastward from the Keystone Ferry Landing past Telaker Shores to Admirals Cove. Most of the wetland is in public ownership, including the federal government, Washington State Parks, the Town of Coupeville and Island County. Island County currently owns about 34 ha east of Keystone Road and south of Wanamaker Road. Admiralty Bay is used for sport and commercial fishing and for recreational boating. There is also an underwater park.

Crockett Lake is a slightly saline, shallow waterbody located in the southwest portion of the Crockett Sub-basin, north of Keystone Road, between Engle Road and Keystone Lagoon. A topographic map from 1870 shows the "lake" and a large wetland system adjoining much of Admiralty Bay (Appendix A-5) (Department of Commerce 1870). The original saltmarsh is

reported to have been separated from saltwater when a roadway servicing Fort Casey was constructed (Entranco Engineers, Inc. and Independent Ecological Services 1986). In the late 1940s and early 1950s most of the lake area was drained for farming (Island County Drainage District No. 6). Around 1950, the Drainage District installed two 76 cm culverts with flap gates at the southwest corner of the lake near the Keystone ferry terminal (Map 7). A pumping station and drainage ditches were also constructed to modify the hydrology of this site. The tide gate was designed to allow water to flow out of Crockett Lake when the lake elevation exceeded tidal elevation. When the tidal elevation surpassed lake elevation, the flow out of the lake would stop and the flap gates would shut. The outlet control structure was eventually abandoned and the facility became inoperable between 1974 and 1983. Following a large storm event in 1983, in which up to .5 m of water covered the roadway (now SR 20), the outlet was repaired and the lake level dropped. This prompted discussion in the community about the optimum water level. In 1986, a study, sponsored by Drainage District 6, WSDOT and WDFW, was conducted to address this issue, focusing on flood control and other historic recreation and wildlife uses (Entranco Engineers, Inc. and Independent Ecological Services 1986).

Island County maps currently show 8.4 km<sup>2</sup> of wetlands in this sub-basin (Map 3). The Crockett Lake wetland area is estimated to cover between 2.4 km<sup>2</sup> and 2.8 km<sup>2</sup> (Sheldon and Associates 1999a). The lake is estimated to cover approximately 1.5 km<sup>2</sup>, and have a mean depth of 1.1 m when the lake is 2.4 m above mean lower low water (MLLW) (FEMA 1995). A 152-m wide strip of gravel separates the lake from Admiralty Bay (FEMA 1995). Today about 60 % of the site is saltmarsh habitat (Sheldon and Associates 1999a). The low saltmarsh is dominated by Virginia glasswort, (*Triglochin maritimum*), Olney's bulrush, seashore saltgrass, and Halberd-leaf saltbush. The high saltmarsh is dominated by dock, (*Rumex sp.*), Puget Sound gumweed (*Grindelia integrifolia*), silverweed, common yarrow (*Achillea millefolium*), bentgrass (*Agrostis sp.*), and various grasses. Mudflats (10 %) and open water (5 %) habitats are located within the saltmarsh. The freshwater marsh comprises about 25 % of the site. It is dominated by willows, cattail, and hard-stem bullrush. The plant community within the ditches is dominated by cattail, hard-stem bullrush (*Scirpus acutus*), Virginia glasswort, Halberd-leaf saltbush, and yellowcress (*Rorippa nasturtium-aquaticum*). About 5 % of the site is covered with invasive exotic species, with the dominant invasive being *Cirsium arvense*.

Admiralty Bay is mapped as supporting a thin band of eelgrass beds along the shoreline (Map 2).

### Cultus (118)

The Cultus Sub-basin is located at the southeast tip of Whidbey Island (Map 1). It is about 8.0 km<sup>2</sup> in size. The sub-basin is drained by Cultus Creek, which flows south into a wetland system, and then Cultus Bay. The shoreline length of Cultus Bay is estimated to be 2.4 km. The WDNR has mapped 2.6 km of Type 2 and 3 Waters in this drainage. The Land is zoned is predominantly as rural (84 %), with the remainder zoned for forest (13 %) and agricultural (3 %) (Map 6).

The east side of the bay is mostly bordered by the Hook Sub-basin. Land use in this 2.5 km<sup>2</sup> drainage is predominantly rural residential. The Sandy Hook residential community includes a number of homes that have been sited on the north-trending spit at the southeast corner of the bay. The shoreline of the spit has been highly modified by private landowners. This community

also operates a private marina within the protected waters east of the spit. Salmon pens are reported to also be located in this area.

A topographic map from 1872 shows an estuary linked by a large channel at the north end of Cultus Bay (Department of Commerce 1872) (Appendix A-6). An east-west trending sand spit bordered the south side of the estuary. This saltwater wetland has since been converted to a freshwater system through the construction of a dike that runs along the spit and the southeast edges of the site in the location of the historic channel (Map 7). The diked portion of the estuary is within a privately owned parcel that is about 81 ha in size. A private residence is located on the spit connecting with the southeast dike. The WDNR provides a public access at the northwest corner of the bay.

The diked portion of the wetland is dominated by weedy grasses and herbs and is grazed by cattle. Brackish emergent plants dominate the eastern, portion of the estuary outside of the dike (Sheldon and Associates 1999c). The major wetland plant communities are dominated by seashore saltgrass and seaside arrow-grass, with Himalaya blackberry (*Rubus procerus*) and cattail along the west end of the site. Invasive exotic species include blackberry, reed canarygrass, purple loosestrife, and *Spartina anglica* (Table 6) (Wahlin 2000).

Eelgrass beds have been mapped at each end of Cultus Bay (Map 2).

#### Deer (117)

The 10.6 km<sup>2</sup> Deer Sub-Basin drains east from its headwaters at Deer Lake into Possession Sound (Map 1). It has 5.4 km of shoreline. The WDNR has mapped about 0.6 km of Type 2 and 3 Waters in this sub-basin that is drained by Deer Creek. Rainfall is between 51 cm and 64 cm per year (KCM 1998). Land use is primarily zoned as rural (89 %) (Map 6). Current land use is primarily rural and shoreline residential, with some commercial/residential, light industrial, forest management, and non-commercial agriculture (KCM 1998).

Deer Lake sits about 107 m above sea level (Appendix A-7). The lake is 0.4 km<sup>2</sup> in size, and about 15 m deep. The 2.7 km shoreline is mainly used for residential purposes. Approximately two-thirds of the shoreline is lined with grass lawns, and there are several bulkheads. The remaining riparian area contains alder, willow and rushes. Deer Lake is one of four lakes monitored by the WDOE as part of the Lake Water Quality Assessment Program. The WDOE has classified the lake as oligo-mesotrophic based on water quality data collected as part of this program. The WDFW owns a public access site on the northeast shore of the lake which is open year round (WDFW 1999a). The agency stocks the lake with rainbow trout and cutthroat trout.

A thin band of eelgrass beds are mapped along most of the shoreline of the Deer Sub-basin (Map 2).

#### Dugualla (7)

Dugualla is the fifth largest sub-basin in WRIA 6. The 18.3 km<sup>2</sup> drainage is located on the northeast side of Whidbey Island and drains to Dugualla Bay (Map 1). Rainfall is between 38 and 51 cm per year. Dugualla Creek originates east of Ault Field and flows northeast to Dugualla Lake, which is located near the mouth of the stream. Water is pumped from the lake over a berm

and into Dugualla Bay. The bay has 3.5 km of shoreline. The WDNR has mapped about 3 km of Type 2 and 3 Waters in the drainage. About 23 % of the sub-basin is zoned as federal land and occupied by NAS Whidbey. Most of the basin (64 %) is zoned as rural, with agriculture (6 %)

Table 6. Estimated area of *Spartina* infestation, WRIA 6 (Wirth 1999).

	1997 Solid	1997 Affected	1999 Solid	1999 Affected
Location	(ha)	(ha)	(ha)	(ha)
<b>Whidbey</b>				
Ala Spit	0.2	2.0	0.0	2.0
Cornet Bay	0.2	4.0	0.0	4.0
Coupeville	0.1	0.4	0.0	0.4
Cultus Bay	16.2	121.4	5.5	121.4
Deer Lagoon	24.3	60.7	6.1	60.7
Dugualla Bay	0.4	8.1	0.2	8.1
Lake Hancock	0.2	4.0	2.0	4.0
Skagit Head	0.0	2.0	0.0	2.0
Oak Harbor	0.0	2.0	0.0	2.0
Penn Cove	0.4	4.0	0.0	4.0
Race Lagoon	0.0	2.0	0.0	2.0
Snakelum	0.1	2.0	0.0	2.0
Sunlight Beach	3.2	10.1	2.0	10.1
<b>Total Whidbey</b>	45.4	223.0	15.8	223.0
<b>Camano</b>				
Arrowhead	0.8	4.0	0.4	4.0
Country Club	0.0	0.8	0.0	0.8
Driftwood Shores	0.0	0.2	0.0	0.2
Eagle Tree	1.4	2.4	0.8	2.4
Elger Bay	2.0	12.1	2.0	12.1
English Boom	4.9	12.1	4.0	12.1
Livingston Bay	25.5	72.8	40.5	80.9
Mt. View	0.4	2.0	0.4	2.0
North Leque/West Pass	105.2	222.6	105.2	222.6
Skagit Bay	40.5	80.9	60.7	80.9
South Leque/Davis Slough	4.5	174.0	2.4	174.0
South Pass	4.0	18.2	1.6	18.2
Sunny Shores	0.8	2.0	0.8	2.0
Triangle Cove	66.0	94.3	64.8	94.3
<b>Total Camano</b>	256.1	698.7	283.7	706.8
<b>Total WRIA 6</b>	301.5	921.7	299.5	929.8

and forest (5 %) making up the rest (Map 6). Drainage District 1 was formed in 1918 for agricultural purposes (Kearsley and Hossley 1995). A petition to dissolve the District was filed in 1965. Diking District 3 was established in 1915 and it remains active.

Dugualla Lake is located east of Ault Field, and receives surface runoff from the naval installation. A topographic map from 1908 shows a large estuary in the location of the lake (Appendix A-8). It was connected by two channels to Dugualla Bay. The lake is now estimated to cover about 22.3 ha when the water level is at mean sea level (FEMA 1995). Island County

maps show 2.76 km<sup>2</sup> of wetlands in the sub-basin (Map 3). Land use around the lake is mostly agricultural. This area experiences periodic flooding when high tide and siltation impede the operations of the two 122-cm culverts connecting the lake with Dugualla Bay. A tide gate, owned by Whidbey NAS, controls the flow (Map 7).

Dugualla Bay is a shallow 1,012-ha triangle-shaped bay that contains a significant amount of eelgrass beds and spawning habitat for Pacific herring and surf smelt (Map 2). *Spartina anglica* is also present (Wahlin 2000).

#### Glendale (119)

The 7.2 km<sup>2</sup> Glendale Sub-basin is located at the southeast corner of Whidbey Island (Map 1). Glendale Creek, one of the three most significant fish-bearing streams in WRIA 6, flows in a southeast direction before draining into Possession Sound. The WDNR has mapped about 3 km of Type 2 and 3 Waters in this drainage. The shoreline length is 1.0 km. Land use is zoned for rural (84 %), forest (13 %), and agriculture (3 %) (Map 6).

This sub-basin is noted for its creek (Appendix A-9). The 3.9 km Glendale Creek is one of only a handful of perennial streams in Island County, and one of the three most significant fish-bearing streams (Base 1999). The stream's headwaters begin from wetlands near Cultus Bay Road (Anderson 1999) at an elevation of about 88 m. From there the stream flows southeast through a narrow forested valley. The lower 183 m of the creek parallels Glendale Road and discharges into Possession Sound at the community of Glendale. Upstream of Glendale Road, the creek is less confined and further from the road. The stream is characterized by a series of plunge pools having residual pool depths of 0.22 m to 0.46 m (Sheldon and Associates 1999b). Much of the upper portion of Glendale Creek possesses very good or excellent habitat (Aquatic Resource Consultants 1997). The lower and upper portions of Glendale Creek support resident cutthroat trout (Johnson 1999). Chum and coho have been using the lower portion of the stream since the winter of 1996-97, when the culvert near the mouth of a stream was destroyed (Anderson 1999; Johnson 1999; Sheldon and Associates 1999b).

The habitat in the upper portion of Glendale Creek consists of mature deciduous forest dominated by red alder and big-leaf maple with scattered Douglas fir and western red cedar (Sheldon and Associates 1999a). The understory is dominated by swordfern and Himalayan blackberry. The riparian area along the lower portion of the stream consists of residential lawns, invasive exotic species, including reed canarygrass and Japanese knotweed (*Polygonum cuspidatum*), and pavement.

#### Hancock (56)

The Hancock Sub-basin is located on the west shore of central Whidbey Island (Map 1). This drainage is 6.2 km<sup>2</sup> in size and has 4.4 km of shoreline. It drains west into southern Admiralty Bay. There are no major streams. Land use is zoned for rural (49 %), forest (35 %), federal (12 %), and agricultural (4 %) use (Map 6). Whidbey NAS owns the federal land that underlies Lake Hancock. About 16 ha are owned by The Nature Conservancy of Washington. This site was placed on the Washington Register of Natural Areas in 1992. Public access is not allowed due to the presence of live ordnance, although some illegal trespass does occur. Lake Hancock receives

special protection because it is the best remaining example of a high quality coastal lagoon and saltmarsh system in WRIA 6. This area contains one of only 10 occurrences of high salinity lagoons, one of only 7 occurrences of the silty, moderate salinity, low marsh, and one of only 5 transition zone wetlands known in the Puget Trough (Chappell, Gamon, Stephens et al. 1996).

Topographic surveys of the coastline conducted in 1870 show a small inlet connecting Lake Hancock to Admiralty Inlet (Department of Commerce 1870) (Appendix A-10). Around the turn of the century Lake Hancock was converted into a predominantly freshwater system and used by farmers to grow cranberries. Saltwater re-entered the wetland through a breached (presumably fortified) sand bar in 1913 during a storm event. Farmers repaired the breach and maintained the sand bar for two decades to maintain the lake as freshwater. In 1934, another storm again caused a breach and the lake was allowed to transition back to a salt water lagoon. Between 1943 and the early 1970s, Lake Hancock was used as a practice bombing range for aircraft stationed at the Whidbey NAS (EA Engineering 1996). Helicopter training exercises are still occasionally held here, but the lagoon is primarily managed for its natural values.

This site is mostly undeveloped and dominated by wetland and forest habitats. Lake Hancock includes, among other habitat types, 46 ha of saltmarsh, 16 ha of coastal lagoon, 11 ha of mudflat, and 4 ha of cobble/sand beach (EA Engineering 1996). The site is bordered by 13 ha of freshwater marsh, scrub-shrub wetland, and a forested bog. It receives regular tidal flooding from Admiralty Inlet through a primary slough and a tidal channel complex. Some of the tidal channels are human-created ditches, a probable remnant from historic agricultural activity. Surface runoff is the only source of freshwater to the system.

Eelgrass beds are mapped in the nearshore area adjacent to Lake Hancock and the shoreline of the Hancock Sub-basin (Map 2). *Spartina anglica* is also present (Table 6)(Wahlin 2000).

### Harrington (30)

The Harrington Sub-basin is located on the east side of central Whidbey Island and drains to Saratoga Pass (Map 1). It is about 1.5 km<sup>2</sup> and has approximately 1 km of shoreline. Land use in the sub-basin is zoned primarily rural (73 %), followed by forest (24 %), and agriculture (3 %) (Map 6). There are no significant streams in this sub-basin, but the drainage does contain a small, relatively healthy lagoon (Harrington Lagoon) situated amidst shoreline residential development. The lagoon is in private ownership and is frequently visited by local residents.

A topographic map, dated 1887-88, shows a small lagoon with a northwest-trending sand spit at the current site of Harrington Lagoon (Department of Commerce 1887-88) (Appendix A-11). Houses are now situated on this spit. Tidal waters are not prevented from entering or retreating from the lagoon, but during a field visit a local resident described a recent change in the configuration of the channel inlet. This could be a result of shoreline modifications that have been imposed by private homeowners. Extensive beds of mussels were observed along the inlet channel during a field visit by the TAG.

The nearshore habitat is mapped to support spawning for Pacific herring and surf smelt (Map 2). *Spartina* may be present (Wahlin 2000).

## Holmes Harbor

Holmes Harbor is a narrow north-south trending embayment on the east side of Whidbey Island that opens to Saratoga Passage (Map 1). The harbor is approximately 9.7 km long and ranges in width from 3.6 km at the mouth to about 1.2 km at Freeland. Depths range from 75 m near the mouth to 26 m near the head of the harbor. Surface salinity is low. Rainfall is 7.9 cm to 9.9 cm per year (KCM 1998). Fourteen small sub-basins drain into this bay. Together these drainages include 27.3 km of shoreline. A few of the drainages (Honeymoon (84) and Freeland (111)) have been identified as having potential for salmonid restoration. Land use is primarily rural residential and residential. Single family residences are scattered along the shoreline along with a few high-density residential areas. There is also a golf course on the west side of the harbor and a boat building company at the head of the harbor, along with the small town of Freeland. All sewage is disposed of into sub-surface sewage disposal systems.

The nearshore habitat associated with Holmes Harbor supports eelgrass beds and spawning habitat for Pacific herring and surf smelt (Map 2).

## Langley (100)

The 5 km<sup>2</sup> Langley Sub-basin is located in the vicinity of the town of Langley on the east shore of south Whidbey Island (Map 1). It drains in a northeast direction into Saratoga Pass. Land use is primarily urban and commercial, with some residential and rural residential (KCM 1998). Rainfall is approximately 7.9 cm to 9.9 cm per year (KCM 1998). This sub-basin is noted because Brookhaven Creek may have potential, with *extensive* restoration, to provide salmonid habitat (Base 1999). Land use is zoned primarily as rural (53 %), urban (27 %), and forest (19 %) (Map 6). About 0.5 % of the sub-basin is zoned for an airport. Brookhaven Creek is piped underground below the City of Langley and discharges at a steep outfall into Saratoga Passage.

## Maxwelton (108)

Maxwelton is the largest sub-basin in WRIA 6 and one of the most important drainages for known and potential salmonid use. The 31.0 km<sup>2</sup> drainage is located on the west side of south Whidbey Island (Map 1). Maxwelton Creek generally flows in a southwest direction from headwaters north of Miller Lake into the Maxwelton estuary and then into Useless Bay. The WDNR has mapped 11.4 km of Type 2 and 3 Waters in this sub-basin. Rainfall is about 7.9 cm to 9.8 cm per year (KCM 1998). The shoreline is about 4.3 km in length. Land use is primarily rural residential, with some forest management, agriculture, shoreline residential and institutional (3 schools) (KCM 1998). This drainage benefits from the stewardship of a non-profit organization known as the Chums of the Maxwelton Salmon Adventure (CMSA). The Chums are committed to restoring and maintaining a yearly salmon run in Maxwelton Creek. The group built and operates a streamside outdoor classroom along Maxwelton Creek between French and Erickson Road.

The lower valley has been farmed since at least 1863 (Bochte and Fitz 1989). The farm fields were originally protected from saltwater by a system of dikes (Bochte and Fitz 1989). The marsh has been used for agricultural purposes, resulting in stream channels being straightened, diked and ditched (Map 7). Around 1916, a storm blew out a dike, allowing saltwater to rush in.



Five years are reported to have passed before crops could again be grown on the reclaimed marsh land. Tidal flows are controlled by a 60-inch tide gate. Diking District 2 is responsible for maintaining the tide gate. Livestock have access to Maxwellton Creek in some locations. During the summer months an indeterminate amount of water is withdrawn from the stream for irrigation (Schule 1996). Maxwellton Road separates the marsh from saltwater. Several houses (dating back to the 1940s) are present on the beach berm. Impervious surfaces are relatively minor.

A topographic map from 1872 shows an estuary at the mouth of Maxwellton Creek (Department of Commerce) (Appendix A-14). At that time a sand spit paralleled the shoreline. The spit was approximately 975 m long, oriented north-south, and its opening to the north was well protected from wave action (Sheldon & Associates 1999). Today the spit is no longer present. The current marsh has been reduced to approximately 69 ha and is dominated by freshwater plants including pasture grasses, reed canarygrass, soft rush, cattail, willow, and red alder (Sheldon and Associates 1999c). An estimated 10 % to 20 % of the plants are invasive exotic species. Freshwater enters the marsh from Maxwellton Creek and Quade Creek at French Road, which joins north of the tide gate.

### Penn Cove (18)

Penn Cove is a narrow east-west trending bay located on the east side of north Whidbey Island (Map 1). The cove is bordered by the Penn, Hastie and Monroe Sub-basins that collectively include 18.1 km of shoreline. Penn Cove is notable for its world-famous mussels. For the purposes of this report, Grasser's Lagoon and Kennedy Lagoon are the main focus of this sub-basin. Both lagoons are located in the Penn Sub-basin at the west end of the Cove. Land use in this watershed is zoned predominantly as rural (46 %), followed by agricultural (22 %), urban (19 %), forest (11 %), and park (2 %) (Map 6).

Grasser's Lagoon is a privately owned lagoon located at the northwest corner of Penn Cove between State Route 20 and Madrona Way. It is shown on an 1871 topographic map as having one main channel connecting to the cove (Department of Commerce 1872) (Appendix A-15). The 16-ha lagoon remains open to tidal flooding and is in relatively good condition. The shape of the lagoon hasn't changed much over time. Surface runoff drains from the hills and the roads into the lagoon. The National Park Service holds a scenic easement for this hill slope (Wahlin 2000). The coastal beach is mostly unvegetated (Sheldon and Associates 1999c). Virginia glasswort is present on the back side of the spit, and Seashore saltgrass is on the grassy beach. *Spartina anglica* is also present (Wahlin 2000) (Table 6). There is virtually no buffer between vegetated mudflats and the roads that surround the wetland.

Kennedy Lagoon is located at the southwest corner of Penn Cove. It is also shown on the 1871 topographic map. A few residential homes are located on the perimeter of the lagoon. In these locations the riparian vegetation has been removed and replaced with lawn. A tide gate is located at the channel inlet. The lake levels appear to be managed for recreational use.

The nearshore of Penn Cove hosts significant surf smelt, sand lance, and Pacific herring spawning areas (Map 2).

### Race (33)

The 6.9 km<sup>2</sup> Race Sub-basin is located on the east side of central Whidbey Island and drains to Saratoga Passage (Map 1). It has about 8 km of shoreline. Zoning is primarily rural (82 %) followed by forest (17 %), and agriculture (less than 1 %) (Map 6). This sub-basin is noted in this report for the presence of a relatively unmodified lagoon (Race Lagoon).

A topographic map from 1887-88 shows a lagoon with an inlet that has been nearly closed off by a northwest-trending sand spit (Department of Commerce) (Appendix A-16). Island County has mapped approximately 0.5 km<sup>2</sup> of wetland habitat currently associated with the lagoon (Map 3).

### Swantown (13)

The Swantown Sub-basin is the sixth largest drainage in WRIA 6, covering about 18.0 km<sup>2</sup>. It is located on the west side of north Whidbey Island west of Oak Harbor and south of Ault Field (Map 1). Drainage flows in a northwest direction via Swantown Creek and its tributaries. The WDNR has mapped 0.22 km of Type 2 and 3 Waters in this sub-basin. There is approximately 2.0 km of shoreline. Land use is approximately 65 % agricultural, 30 % forestry, and 5 % residential (Island County Public Works 1997). The developed portion of the watershed has been extensively landscaped and includes a golf course (Whidbey Golf and Country Club) and a number of homes. Residential development from Oak Harbor is increasing rapidly in the upland areas. Stormwater runoff volumes have reportedly increased due to development in the upper watershed (Map 5). Whidbey Golf and Country Club is located in a low-lying area midway in the drainage basin, and is prone to severe flooding. The development includes two stormwater detention ponds. (FEMA 1995). The lowermost portion of the basin has been historically devoted to agriculture. Drainage District 1 was established in 1918 within this area. At around that time farmers installed a dike, tide gates, and a pump near Sunset Beach to drain the lowland area for pasture (Map 7). The District formally dissolved in the winter of 1978-79 due to a lack of support from land owners in the upper part of the basin.

Swantown Creek is now intermittent and much of the stream has been channelized. It is not known to support salmonids at this time, but has potential salmonid habitat with restoration (Johnson 1999). The stream drains to a brackish wetland called Swantown Marsh (also known as Swan Lake or Bos Lake), located near the coastline just east of West Beach Road and west of Swantown Road. The hydrology of the marsh was reportedly altered by the construction of West Beach Road.

A topographic map from 1871 shows a wetland and open water area that appears to be separated by a natural beach berm from Puget Sound (Department of Commerce 1871) (Appendix A-17). Today a tidal gate connects the marsh with the Sound, and the current wetland size is estimated to be approximately 40 ha. The wetland occupies approximately 15 parcels. In 1918, the wetland area was mapped as covering 16 ha. Since then, the area has been pumped and farmed. The area has been inundated by water and not pumped since the late 1970s. The lake level fluctuates seasonally. A storage ditch runs parallel to the shoreline and drains the remainder of the low-lying area. A row of houses stands between the shoreline and the ditch. A pump has been used to alleviate backflooding problems during high tide and periods of high precipitation. Island County owns most of the land that includes the marsh habitat (Kearsley 2000).

Swantown Marsh is only partially functioning as saltmarsh habitat. About 40 % of the wetland currently exists as saltmarsh habitat, the remainder being freshwater marsh (40 %), mudflat (20 %), and open water (10 %) (Sheldon and Associates 1999c). The saltmarsh is dominated by saltmarsh bulrush (*Scirpus maritimus*). The mudflat surrounding the open water is dominated by saltmarsh bulrush, Virginia glasswort, seashore saltgrass, and Halberd-leaf saltbush. Virginia glasswort, seashore saltgrass, Halberd-leaf saltbush, and silverweed dominate the westernmost ditch and berm. The north extension of the wetland is dominated by silverweed, Olney's bulrush, cattail, (*Epilobium watsonii*), and soft rush. Invasive exotic species do not appear to be a problem at this site.

Some eelgrass beds have been mapped along the shoreline of this sub-basin (Map 2).

#### Useless (99)

The Useless Sub-basin is located on the southwest side of south Whidbey Island (Map 1). It is the third largest sub-basin in WRIA 6 covering 30.5 km<sup>2</sup>. The sub-basin includes 11.4 km of shoreline. Lone Creek drains this sub-basin. It flows in a southerly direction from the headwaters north of Lone Lake into Deer Lagoon and then into Useless Bay. The WDNR has mapped about 0.6 km of Type 2 and 3 Waters in this drainage. Lone Lake is about 5.2 m above sea level and is fed by two small inlets. The lake is 41 ha in size and 5.2 m deep. Residential development is located around Lone Lake and along Sunlight Road parallel to the 2.6 km shoreline. Land use is zoned primarily rural (78 %), followed by forest (11 %), and agricultural (8 %) (Map 6). Airport zoning occupies 0.2 % of the land in the sub-basin.

Prior to human development, Deer Lagoon was one of the largest estuaries in WRIA 6. It is located between Useless Bay (south), Double Bluff Road (west), Millman Road (north) and Bayview Road (east). A topographic map from 1872 shows that the lagoon was originally connected by a large channel to Useless Bay (Department of Commerce 1872) (Appendix A-18). It is now a highly modified wetland system. Lone Creek and three other streams flow into the wetland. The current width of the channel connecting to Useless Bay is about 84 m. The wetland is presumed to have been developed for agriculture purposes in the early 1900s (Sheldon and Associates 1999a). This area was diked, ditched and dredged (Map 7). Diking District 1 owns a system of dikes which effectively divides the wetland into three sections (Sheldon and Associates 1999a). Most of the land is private, and includes a large tract in the western portion of the lagoon owned by H and H Properties (Wahlin 2000). Washington State Parks owns land in the vicinity of the eastern portion of the lagoon. Numerous residential homes are sited on the beach berms separating Deer Lagoon from Useless Bay on each side of the channel mouth. Water is pumped across the east dike at the northeast corner of the lagoon. A golf course and several homes north of the wetland were constructed in the past 10 to 15 years. This development has resulted in extensive alteration of the wetland and streams feeding the lagoon.

Deer Lagoon and the nearshore of Useless Bay support eelgrass beds (Map 2). *Spartina anglica* is also present (Table 6) (Wahlin 2000).

## Camano Island and Sub-basins

Camano Island is located between Whidbey Island and the mainland of Washington State. It is the second largest island in Puget Sound. Camano Island is bounded by Skagit Bay (north), Saratoga Passage (west), Possession Sound (south) and Port Susan (east). It is approximately 24 km long, 1.6 km to 11 km wide, covers 104.3 km<sup>2</sup>, and includes 85.0 km of shoreline. The WDNR has mapped 3.1 km of the streams as Type 2 and 3 Waters. The coastal shoreline of Camano Island is a Type 1 water, a Shoreline of State Significance. About 25 % of Camano Island is in an open agriculture or forest/timber tax program (KCM 1998). Approximately 50 % of the residential parcels, comprising about 48 % of the land area were undeveloped as of 1998 (KCM 1998).

Forty sub-basins have been delineated within Camano Island, the largest being Livingston, and Triangle (Appendix A-2, Map 1). This section of the report describes the sub-basins within Camano Island deemed most important for salmon.

### Boom (16)

The 5.2 km<sup>2</sup> Boom Sub-basin drains the northeast side of Camano Island into Davis Slough (Map 1). It includes 9.3 km of shoreline. Land use is zoned predominantly for rural (70 %) and agricultural (27 %) land use (Map 6). In 1997, Island County acquired 2 ha of land that includes about 0.8 ha to 1.2 ha of the English Boom saltmarsh. North of English Boom is an area known as Eagle Tree Estates. This property includes community-owned tidelands and a lagoon known to support fish (Wahlin 2000). The English Boom wetland is the focus of this sub-basin.

English Boom is a long northwest-southeast trending beach that historically had an extensive pier system (Sheldon and Associates 1999c). A topographic map from 1889 shows a saltmarsh connected by at least one large channel to Davis Slough (Department of Commerce 1883) (Appendix A-19). Today the English Boom saltmarsh is approximately 40 ha in size and runs parallel to Davis Slough. The marsh has formed behind the natural beach berm in backwater tidal channels. The vegetation is dominated by native, salt-tolerant emergent species and invasive *Spartina alterniflora* (Sheldon and Associates 1999c). Virginia glasswort, seashore saltgrass, fleshy jaumea (*Jaumea carnosa*), and (*Spartina anglica*) dominate the channels. The berms are dominated by Puget Sound gumweed, fescue (*Festuca sp.*), and (*Cytisus scoparius*). *Spartina anglica* dominates the water's edge, and is estimated to cover about 10 % of the site (Table 6) (Sheldon and Associates 1999c). The channels are open to salt water during high tide.

### Carp (28)

The Carp Sub-basin is located on the northeast side of Camano Island (Map 1). It is about 6 km<sup>2</sup> and has 2.4 km of shoreline. Carp Creek drains the basin, flowing east to Saratoga Passage. The WDNR has mapped approximately 0.7 km of Type 2 and Type 3 Waters in this stream system. Land use in the sub-basin is zoned primarily as rural (83 %) and forest (16 %) (Map 6). The basin is noted in this report for its potential salmon habitat. Salmonids have been documented along the nearshore area (Map 2).

### Cavalero (32)

The Cavalero Sub-basin is located immediately south of the Triangle drainage (Map 1). Cavalero Creek drains west to Port Susan. It is about 3 km<sup>2</sup> and has 1.6 km of shoreline. Ninety-nine percent of the drainage is zoned for rural land use (Map 6). The sub-basin is noted for potential salmon habitat.

The nearshore supports spawning habitat for Pacific herring and surf smelt (Map 2).

### Elger (43)

The Elger Sub-basin is located on the west coast of central Camano Island (Map 1). The 6.7 km<sup>2</sup> drainage drains south into Elger Bay. It includes 2.1 km of shoreline. Land use is zoned predominantly for rural (91 %) land use (Map 6). Forest (6 %) and park zoning designations comprise the remainder of the sub-basin. This sub-basin is noted in this report for the saltmarsh located adjacent to Elger Bay.

An 1887-88 topographic map shows a saltmarsh connected by a channel to Elger Bay (or Elgers) (Department of Commerce) (Appendix A-22). Today the marsh is mostly separated from the bay by a sandy berm that does not appear in the historic map. The channel connecting the marsh to Puget Sound is in approximately the same location. The marsh is choked with thousands of logs. A few older houses have been constructed on the beach berm and the open areas are platted for more single family view homes. A residential development surrounds the upland side of the marsh. This development is reported to have a conservation easement mandating protection of the marsh.

### Livingston (20)

The Livingston Sub-basin is the largest drainage on Camano Island and the eighth largest in WRIA 6. The drainage covers 13.7 km<sup>2</sup> and includes 10 km of shoreline. It is located on the east shore of Camano Island (Map 1). It drains south into Livingston Bay which is connected to Port Susan. Land is zoned for rural (69 %), agricultural (28 %), and forest (7 %) use, as well as for an airport (0.2 %) (Map 6). Drainage District 5, organized in 1934, is located in this drainage which is still being farmed.

A topographic map, dated 1886, shows an estuary at the southwest corner of Livingston Bay (Department of Commerce 1886) (Appendix A-23). Known as the "Iverson property," this land, has been ditched, drained and diked, and is still being farmed (Map 7). The marsh is bounded on the southeast by Iverson Road and numerous private residences, and on the northwest by a dike. Tidal waters historically entered the saltmarsh through the dike at the northwest corner of the site. The channel is now blocked by a tide gate. *Spartina anglica* dominates about 75 % of the emergent wetland outside of the dike (Table 6) (Sheldon and Associates 1999c). Island County recently acquired about 28 ha of farm land on the southeast side of Livingston Bay along Iverson Road. The County is leasing the property for continued farming until December 31, 2001.

Livingston Bay supports a number of eelgrass beds (Map 2).

### Triangle (26)

The Triangle Sub-basin is located on the east shoreline of central Camano Island (Map 1). It is the second largest drainage on Camano Island and the eleventh largest in WRIA 6, covering 12.3 km<sup>2</sup>. Drainage flows south via Kristofferson Creek from the headwaters north of Kristofferson Lake into the Triangle Cove estuary and then into Port Susan. The WDNR has not mapped any Type 2 or Type 3 Waters in this sub-basin but the stream is believed to have potential to support salmonids (Base 1999; Johnson 1999). There is 7 km of shoreline. Land use is primarily rural residential and residential, with some commercial, light industrial, recreational (golf course), institutional (County annex and road shop), agriculture, and forest management (KCM 1998). Triangle Cove is owned by one private landowner.

The Triangle Cove estuary is located at the mouth of Kristofferson Creek between East Camano Drive (west), Russell Road (north) and Port Susan (south). An 1886 topographic map indicates that the shape of the cove and sand spit have remained relatively unchanged (Department of Commerce 1886) (Appendix A-24). Approximately 70 % of the wetland is saltmarsh habitat, the remainder being mudflat (20 %), open water (10 %), and freshwater marsh (less than 1 %) (Sheldon and Associates 1999). Approximately 32 ha of the marsh are invaded by *Spartina anglica* (Table 6) (Wahlin 2000). The estuary is mostly within private ownership and is currently estimated to be about 91 ha. Island County purchased approximately 2 ha of land north of the Cove in 1997. This parcel is not adjacent to the stream. Several houses, probably dating back to the 1950s, line the sand spit separating Triangle Cove from Port Susan. The gravel road at the north end of the Cove is at least 30 years old (Sheldon and Associates 1999c).

### Utsalady (23):

The Utsalady Sub-basin is located on the north end of Camano Island (Map 1). It covers 127 km<sup>2</sup> and drains north into Skagit Bay. Land use is zoned primarily as rural (96 %) with a minor amount of forest (4 %) (Map 6).

The shoreline of this sub-basin is the only designated nearshore “Aquatic Conservancy” in Island County’s Shoreline Master Program. This designation, which resulted from a petition by the citizenry, severely limits certain types of future development (Wood 2000). The nearshore habitat provides surf smelt spawning habitat, and has significant seagrass beds (Map 2). The Island County Marine Resources Committee has been awarded a federal grant to fund an underwater videographic survey and mapping of this site and five other nearshore areas (Maxwelton, Crescent Harbor, Oak Harbor, Penn Cove, and Holmes Harbor).

No additional information on habitat factors is provided in this document.

## **Other WRIA 6 Islands**

### Smith Island

Smith Island is located west of Whidbey Island in Rosario Strait. Smith Island and a small unnamed island to the northwest are two of eighty-three rocks, reefs and islands within the San Juan Islands National Wildlife Refuge, administered by the US Fish and Wildlife Service. The Refuge began in 1914 with the establishment of Smith Island Reservation in 1914 under Executive Order 1959. This federal designation provided protection of breeding grounds and

winter sanctuary for nesting sea birds. The Refuge is generally managed as wilderness with the exception of Smith and a handful of other islands pursuant to Public Law 94-577.

Because Smith Island is managed for sea birds there is virtually no information available concerning the nearshore habitat. Biologists who have conducted surveys on Smith Island have noticed two general trends pertaining to nearshore habitat: the kelp beds are shrinking and bottom fish are “almost non-existent” (Ryan 2000).

#### Baby Island

Baby Island is owned by the Tulalip Tribes. There is little information available on the status of nearshore habitat. The Tulalip Tribe’s shellfish biologist reports that there are extensive intertidal and subtidal eelgrass beds surrounding the island (Toba 1999).

## **DISTRIBUTION AND CONDITION OF STOCKS**

### **Historical Condition**

Virtually no historical information concerning the presence of anadromous salmonids in WRIA 6 streams or estuaries was located in the course of preparing this report. Some local residents reported seeing “salmon” or knew of someone that had seen “salmon” in locations where the fish are yet to be documented. A systematic interview of long-time County residents is probably the only way to obtain an historic perspective of fish presence in this area.

### **Fisheries**

What we do know is that the islands in WRIA 6 are located at the junction to Puget Sound and in front of some of the most productive salmon-producing rivers (Snohomish, Stillaguamish, Skagit) in western Washington. Accordingly, this area has served as “one of the most important and critical” harvest areas for commercial and sport fisheries” (Williams et al. 1975). The more productive commercial fisheries in WRIA 6 have been off of West Beach, Lagoon Point, Bush Point, Double Bluff, Indian Point, the west side of Possession Sound, Camano Head, and the southern half of Skagit Bay (EA Engineering 1996). Important sport fishing areas include West Beach, Hope Island, Deception Pass, Possession Point, Admiralty Inlet, Holmes Harbor, Camano Head, Port Susan, and Saratoga Passage.

Some saltmarshes on Whidbey Island have been used for fisheries production. Between 1961 and 1967, weirs were maintained at the ends of the tidal channel bisecting Maylor’s Marsh near Oak Harbor to create a rearing pond for chinook, coho and chum salmon fry (Williams et al. 1975). Crockett Lake was used by the Washington Department of Fisheries (now WDFW) in the 1960s for fishery purposes (Entranco Engineers, Inc. and Independent Ecological Services 1986).

### **Freshwater Habitat**

In the mid-1970s, *A Catalogue of Washington Streams and Salmon Utilization* (Williams et al. 1975) identified 76 independent streams, totaling 140 km in WRIA 6. The streams that appear on the maps used in this report are from the most recent version of the WDNR Hydrology map. This database, which is maintained by the state, currently show about 31 km of Type 2 and Type 3 Waters on Whidbey Island, and about 3 km of Type 2 and Type 3 Waters on Camano. Most WRIA 6 streams are intermittent or ephemeral, and generally do not provide a sufficient flow of water to support salmonids. Others, such as Maxwellton and Glendale Creeks on Whidbey Island, are *presumed* to flow throughout their length year-round and to support small populations of resident and anadromous salmonids.

Six sub-basins in WRIA 6 are currently known or presumed to support salmonids: Onamac (Chapman Creek), Cultus, Duguala, Glendale, Houston (North Bluff Creek),



and Maxwellton (Table 7). Ten more sub-basins have been identified as having potential to provide salmonid habitat: Carp, Crescent, Deer, Langley (Brookhaven and Saratoga Creeks), Honeymoon, Triangle (Kristofferson Creek), Useless (Lone Creek), Brighton (Old Clinton Creek), Swantown, and Thunder (Cavalero Creek). Freshwater fish distribution is shown in Maps 8 through 13.

The streams in Island County are treasured by local residents, but they have not received much attention from fisheries managers because they are too small to support commercial runs. Accordingly, there has yet to be a systematic survey of existing salmonid habitats and populations. The upstream endpoint of distribution for each species can only be estimated at this time and will need field verification. No information was found on the distribution or size of any historic populations. Most of the information documenting fish presence was gathered by WDFW personnel as part of culvert and flow inventories conducted for regulatory purposes (Base 1999). The estimated timing of freshwater life stages for each of the species discussed in this report is shown in Table 1.

### **Nearshore and Estuarine Habitat**

Although WRIA 6 lacks the large freshwater river systems found in other parts of Puget Sound, it does provide more than 331 km of nearshore habitat that is critical to the development of juvenile salmonids. All species of juvenile salmon use nearshore habitats in Puget Sound at either the fry and/or smolt life stages (Levings and Thom 1994). Juvenile salmon migrate through and depend upon many types of nearshore habitat (PSWQA 1990). Marshes and kelp beds provide food and habitat for juvenile salmonids. Mudflats and eelgrass support diverse invertebrate populations that provide food. Rock-gravel habitats also provide food, particularly amphipods. Adult salmon also depend on nearshore habitats to meet some of their migratory needs. Salmon also differentiate between the different habitat types found in estuary ecosystems (Table 8) (Shreffler and Thom 1993).

There has been no systematic survey of salmonid use of nearshore and estuarine habitats in WRIA 6. The information that is provided herein was taken primarily from six sources: 1) baseline nearshore fish surveys of north Puget Sound conducted in the mid-1970s (Miller et al. 1977); 2) nearshore and demersal fish survey of Puget Sound (late 1970s); 3) annual WDFW surveys of pink and chum fry (Hendrick 1999); 4) salmonid data collected incidentally as part of the WDF herring recruitment studies (1979-1985) (Penttila 1999); 5) a study of chinook restoration in the Skagit watershed that includes data from north Whidbey Island (Hayman, Beamer and McClure 1996); and 6) Snohomish River outmigration studies (1986-1987) (RW Beck and Associates 1986; Beauchamp et al. 1987).

The first two studies provide more general information. Data from the latter four studies were collectively used to document nearshore fish use at select locations in WRIA 6 (Maps 8 through 13). The nearshore habitat that has not been surveyed is presumed to

Table 7: Freshwater Fish Distribution in WRIA

Sub-basin	Stream	WRIA No.	Species	Status	Sources	Comment
Whidbey						
Brighton	Old Clinton	0027	Ct	Po	D. Base	
Brighton	Old Clinton	0027	Ch	Po	R. Johnson	
Crescent	Crescent	0027	Ct	Po	R. Johnson	
Crescent	Crescent	0027	Co	Po	R. Johnson	
Crescent	Crescent	0027	Ch	Po	R. Johnson	
Cultus	Cultus	0026	Ct	Pr	D. Base	
Cultus	Cultus	0026	Co	Po	D. Base	
Cultus	Cultus	0026	Ch	Po	D. Base	
Cultus	Unnamed	0028?	Ct	Po	D. Base	Scatchett Head
Deer	Deer	0024	Ct	Po	D. Base	
Dugwalla	Dugwalla	0001	Ct	K	WDFW (per J. Kearsley)	
Glendale	Glendale	0025	Ct	K	D. Base	
Glendale	Glendale	0025	Co	K	D. Base	
Glendale	Glendale	0025	Ch	K	R. Ramsey	non-native?
Honeymoon	Honeymoon	none listed	Ct	Po	D. Base	lake stocked w/rainbows
Houston	North Bluff	0006	Ct	K	D. Base	
Houston	North Bluff	0006	Co	Po	D. Base	
Langley	Brookhaven	0022?	Ct	Po	D. Base	extensive restoration required
Langley	Saratoga	0021?	Ct	Po	D. Base	
Maxwelton	"Bailey Road"	none listed	Ct	K	D. Base	
Maxwelton	Maxwelton	0029	Ct	K	D. Base	
Maxwelton	Maxwelton	0029	Ch	K	L. Fox	introduced in 1994
Maxwelton	Maxwelton	0029	Co	K	L. Fox	introduced in 1979
Maxwelton	Quade	0032	Ct	K	D. Base	
Maxwelton	Quade	0032	Co	K	WDFW Stream Cat.	non-native?
Maxwelton	Quade	0032	Ch	K	WDFW Stream Cat.	non-native?
Maxwelton	Unnamed	0030	Ct	Po	D. Base	
Maxwelton	Unnamed	0030	Ch	Po	D. Base	
Maxwelton	Unnamed	0030	Co	Po	D. Base	
Maxwelton	Unnamed	0031	Ct	Po	D. Base	
Swantown	Swantown	0055	Ct	Po	R.Johnson/Stream Cat.	bullfrogs may be present
Swantown	Swantown	0055	Ch	Po	R.Johnson/Stream Cat.	
Swantown	Swantown	0055	Co	Po	D. Base	
Useless	Lone	0037	Ct	Po	R.Johnson/Stream Cat.	
Useless	Lone	0037	Co	Po	R.Johnson/Stream Cat.	
Useless	Lone	0037	Ch	Po	R.Johnson/Stream Cat.	
Camano						
Carp	Carp	0073	Ct	Po	D. Base	
Onamac	Chapman	0070	Ct	K	D. Base	golf course stocks carp
Onamac	Chapman	0070	Co	Po	D. Base	bullfrogs may be present
Onamac	Chapman	0070	Ch	Po	D. Base	golf course stocks carp
Thunder	Cavalero	0065	Ct	Po	R. Johnson	
Triangle	Kristofferson	0062	Ct	Po	R. Johnson/D. Base	
Triangle	Kristofferson	0062	Co	Po	D. Base/Stream Cat.	
Triangle	Kristofferson	0062	Ch	Po	D. Base/Stream Cat.	
Triangle	Unnamed	0063	Ct	Po	D. Base	ephemeral; ditched
Triangle	Unnamed	0063	Co	Po	D. Base	ephemeral; ditched
Triangle	Unnamed	0063	Ch	Po	D. Base	ephemeral; ditched

Table 8. General estuary habitat use by salmonid species (modified from Shreffler and Thom 1993).

Species	Upland Freshwater-----							Open Saltwater
	Emergent Marsh	Mudflat	Sandflat	Gravel/Cobble	Eelgrass	Soft Substrate	Hard Substrate	Water Column
Chinook Salmon	X		X					X
Chum Salmon	X	X			X			X
Coho Salmon				X				X
Pink Salmon				X			X	
Steelhead								X
Char				X				
Cutthroat Trout	X			X				

support juvenile salmonids. The timing of the nearshore life history phases for salmonids that have been documented in this habitat in WRIA 6 is shown in Table 2.

As discussed previously in this report, Whidbey and Camano Islands historically supported a number of estuaries and other nearshore ecosystems. Most of these sites have been heavily modified by agricultural, residential and other land uses. Some offer outstanding restoration opportunities. Other nearshore sites are still functioning with natural processes but are under private ownership and vulnerable to future disturbance. Estuaries, saltmarshes and lagoons in WRIA 6 that have presumed or potential fish distribution are listed in Table 9 and shown in Maps 8 through 13.

Table 9. Nearshore fish distribution in WRIA 6.

Island	Sub-basin	Stream	Wria No.	Name	Status	Barrier	Comment
Whidbey	Cultus	Cultus	0026	Cultus Bay	Pr/Po	X	tidegate, dike
Whidbey	Maxwelton	Maxwelton	0029	Maxwelton	Pr/Po	X	tidegate, active farming
Whidbey	Useless	Lone	0037	Deer Lagoon	Pr/Po	X	tidegate, dikes
Whidbey	Hancock	NA	NA	Lake Hancock	Pr		potential monitoring control site
Whidbey	Crockett	NA	0053	Crockett Lake	Pr/Po	X	tidegate, drainage ditches, ferry landing
Whidbey	Swantown	Swantown	0055	Swantown	Po	X	blocked by tidegate, ditches
Whidbey	Dugualla	Dugualla	0001	Dugualla	Po	X	blocked by tidegate; active farming
Whidbey	Crescent	Crescent	0002	Crescent Marsh	Pr/Po	X	tidegate opened in '94; ditched/diked in 30s
Whidbey	Oak Harbor	NA	NA	Maylor's Marsh	Pr/Po	X	juv. salmon raised in 70s; formerly diked
Whidbey	Penn	Unnamed	NA	Grasser's Lagoon	Pr		potential monitoring control site
Whidbey	Penn	NA	NA	Kennedy Lagoon	Pr/Po	X	partial blockage by tidegate
Whidbey	Holmes	Unnamed	0010	Holmes Harbor	Pr	X	tidegates block spawning in small creeks
Whidbey	Harrington	NA	NA	Harrington Lagoon	Pr		potential monitoring control site; mussels
Whidbey	Race	NA	NA	Race Lagoon	Pr		potential monitoring control site; mussels
Whidbey	Berry	NA	NA	Greenbank	Po	X	tidegate, dike
Camano	Triangle	Kristoferson	0063	Triangle Cove	Pr/Po	X	culvert blockage, spartina, partial dike
Camano	Livingston	NA	NA	Iverson	Po	X	County owned, tidegate, dike
Camano	Livingston	NA	NA	Livingston Bay	Po	X	currently farmed
Camano	Elger	NA	NA	Elger Bay	Po	X	choked with drift logs, future development
Camano	Boom	NA	NA	English Boom	Pr/Po		some County property

### North Puget Sound Nearshore Fish Survey

In a 25-month period between 1974 and 1976, (Miller et al. 1977) surveyed the nearshore fish communities of north Puget Sound. The study area included the San Juan Islands but did not include any islands in WRIA 6. Juvenile chum and pink salmon and adult chinook salmon were of the ten most common demersal (bottom-dwelling) species encountered in beach seines in the San Juan Island study sites, while juvenile and adult chinook salmon and juvenile sockeye salmon were of the ten most common species encountered with this method in the nearshore study sites bordering the Skagit and Nooksack watersheds. Gravel habitats supported the highest mean species richness, fish density, and standing crop. The mud/eelgrass, sand/eelgrass, and cobble habitats followed with respect to these variables.

Juveniles of all five species of Pacific salmon were found in the first year of their marine life in all nearshore habitat types associated with the neritic (shallow water) environment in north Puget Sound (Miller et al. 1977). Juvenile chinook, chum and coho salmon were of the ten most common neritic species encountered by tow nets in the Miller et al. (1977) survey. Catches of neritic juvenile salmonids were consistently greater at the northeastern study sites, than at the San Juan sites.

### Puget Sound Nearshore and Demersal Fish Survey

Wingert and Miller (1979) conducted a distributional study of nearshore and demersal fish communities from 235 fish collected at 27 sites throughout Puget Sound. There were at least two nearshore study sites from WRIA 6 included in this study, West Beach and Alexander's Beach. One of the main conclusions from this study was that 58 of the 80 species used in the analysis of nearshore fishes could be grouped together into 12 distinct species groupings. One of the groupings included sand lance, chum salmon and coho salmon. They also found that chum salmon and coho salmon occurred exclusively in sites from north Puget Sound nearshore areas and in a variety of habitats; however, they had a preference for gravel, cobble, and non-vegetated habitats. Most of the occurrences of these two species were during the summer at sites located on the southwest side of San Juan Island. The sand lance-chum-coho grouping was also found during the spring at West Beach. Pink salmon and chinook salmon data were evaluated as part of this study, but neither species fell into one of the 12 species groups.

### WDFW Pink and Chum Fry Nearshore Surveys

The WDFW conducts annual chum fry surveys at select index areas along the east and north shoreline of Whidbey Island and the southeast and northwest shoreline of Camano Island. The visual surveys are conducted from February through mid-June. Peak counts are normally in April for pinks and in May for chum. Data for each index site are available from the mid-1960s and are summarized as graphs in Appendix A-25 and depicted in Maps 8 through 13. The survey data from WRIA 6 nearshore areas are used

to forecast the number of adult pink and chum salmon returning to the Snohomish and Stillaguamish Rivers (Hendrick 1999).

#### WDF Herring Recruitment Studies

Juvenile salmonids were sampled incidentally between 1979 and 1985 as part of the WDF herring recruitment studies (Table 10; Maps 8 through 13). The study area included 13 shoreline sampling stations in WRIA 6, 10 on Whidbey Island and 3 on Camano Island. The nearshore fish samples were collected at night (generally during new moon conditions) during the summer using a surface tow net. Because the focus of this study was on forage fish, the salmonid field data had not previously been analyzed or reported. When reviewing this data, it is important to remember that the data collection times, locations, and sampling method were intended to target forage fish and not juvenile salmonids. Juvenile chum salmon were caught most often, totaling 865 for all survey sites. They were followed by pink salmon (544), chinook salmon (147), coho salmon (60), and coastal cutthroat (1). Data for each species is summarized in Appendix A-26.

Table 10. Juvenile salmonids counted as part of the WDFW forage fish inventories, 1979-1985, WRIA 6 (Penttila 1999).

<b>Location</b>	<b>Pink</b>	<b>Chum</b>	<b>Chinook</b>	<b>Coho</b>	<b>Cutthroat</b>
<b>Whidbey</b>					
Admiralty Bay	0	24	1	3	
N. Lagoon Pt.	15	110	5	3	
N. Bush Pt.	493	368	8	1	
S. Mutiny Bay	5	248	77	36	
Useless Bay	31	28	6	5	
Central Useless Bay		4	1	0	
Possession Pt.		0	3	1	
N. of Randall Pt.		58	17	4	
S. Sandy Pt.		1	0	1	
N. Sandy Pt.		5	9	2	
<b>Camano</b>		0	0	0	
Camano Head		9	2	0	
S. Camano		10	16	4	1
N. Tillicum Beach		0	2	0	
	544	865	147	60	1

#### Skagit Watershed Chinook Restoration Study

In 1995, the Skagit System Cooperative gathered data on juvenile chinook and other salmonids in the mainstem and estuary of the Skagit River and in Skagit Bay as part of their chinook restoration research (Hayman, Beamer and McClure 1996). The Skagit Bay study area included 11 sample sites on the northeast corner of Whidbey Island near Ala Spit and Hoypus Point (Maps 8 through 13). The objectives of the bay sampling portion

of the study were to test the feasibility of different sampling techniques and time periods for sampling juvenile chinook, and to identify important juvenile chinook life history types. The researchers assumed that all juvenile chinook caught in Skagit Bay originated from the Skagit River. The spring and summer/fall Skagit River chinook populations comprise the largest natural chinook runs in Puget Sound.

Within Skagit Bay, the juvenile salmonids were sampled by beach seine and tow net surface trawling. Beach seines were used to sample fish in the intertidal area, while tow net sampling was intended for deeper waters. Beach seines were used two days per month from May through October. The highest beach seine catches of juvenile chinook and other salmonids occurred near high tide. In order of decreasing abundance, the species counted in the study area included chum (20,604), sockeye (539), coho (381), chinook (377), searun cutthroat (22), char (8), and steelhead (6) (Table 11).

Table 11. Juvenile salmonids collected by SSC beach seines in north Skagit Bay, 1995 (Hayman, Beamer and McClure 1996).

Species	11-May	19-May	8-Jun	16-Jun	30-Jun	19-Jul	18-Aug	31-Aug	18-Sep	27-Oct	Total
Chinook	52	34	84	52	61	64	12	15	3	0	377
Coho	28	329	15	4	5	0	0	0	0	0	381
Chum	13,121	7,204	236	33	7	0	3	0	0	0	20,604
Sockeye	11	402	3	82	37	4	0	0	0	0	539
Steelhead	0	0	3	3	0	0	0	0	0	0	6
"Trout"	2	2	12	2	2	0	2	0	0	0	22
Dolly Varden	1	0	4	2	1	0	0	0	0	0	8

The relative number of the juvenile salmon counted at Ala Spit (A) and Hoypus Point (H) follow the trends observed in north Skagit Bay. These two study sites accounted for a significant portion of the total sample size of sockeye (95%), coho (78%), chum (49%), searun cutthroat (41%), and chinook (29%) (Table 12). The habitat in the two study sites consisted predominantly of cobbles on moderate- (Hoypus Point) to steep-slopes (Ala Spit).

#### Snohomish River Juvenile Salmon Outmigration Study

In 1986 and 1987, the Tulalip Tribes initiated a juvenile salmon outmigration study of the Snohomish River (RW Beck and Associates 1986; Beauchamp et al. 1987). The purpose of the study was to gain information on the timing and duration of juvenile salmon migrations through the lower Snohomish River and local marine waters of Possession

Table 12. Juvenile salmonids sampled by SSC beach seines at Hoypus Point (H) and Ala Spit (A), Whidbey Island, 1995 (Hayman, Beamer and McClure 1996).

		Species						
Date	Site	Chinook	Coho	Chum	Sockeye	Steelhead	"Trout"	Dolly Varden
11-May	H	7	1	6300	2	0	0	0
	A	1	0	1050	0	0	1	0
19-May	H	15	41	2548	400	0	0	0
	A	13	24	45	0	0	0	0
8-Jun	H	4	0	63	0	0	2	0
	A	3	2	83	1	0	6	0
16-Jun	H	0	1	15	7	0	0	0
	A	12	0	6	67	0	0	0
30-Jun	H	0	0	0	0	0	0	0
	A	20	2	1	32	0	0	0
19-Jul	H	21	0	0	3	0	0	0
	A	0	0	0	0	0	0	0
18-Aug	H	0	0	0	0	0	0	0
	A	7	0	1	0	0	0	1
31-Aug	H	0	0	0	0	0	0	0
	A	4	0	0	0	0	0	0
18-Sep	H	0	0	0	0	0	0	0
	A	1	0	0	0	0	0	0
27-Oct	H	0	0	0	0	0	0	0
	A	0	0	0	0	0	9	1
	<b>Total</b>	108	71	10112	512	0	18	2
	<b>% Skagit Bay</b>	29	78	49	95	0	41	13

Sound and Port Susan. The focus of the study was on juvenile pink, chum, chinook and coho salmon. Coastal cutthroat, juvenile steelhead, and Dolly Varden were also captured on occasion, but that data was not analyzed in the reports.

During the 1986 season, samples were collected with beach seines at 5 river and 16 marine sites, including 2 sites on south Whidbey Island near Possession Sound and 3 sites on the east side of Camano Island bordering Port Susan. Sampling for 9 of the 16 marine sites occurred weekly from March 31 through July 18, 1986. Additional marine sites were included during the sixth week of the 1986 season, and the sampling period extended until August 14. In 1987, the sampling period extended from March 30 through July 17. Fish samples were collected at 5 river and 20 nearshore marine sites, including the 5 WRIA 6 sites described above. All of the marine study sites were located in nearshore sublittoral waters less than 2 meters deep. Table 13 shows the period of outmigration for three salmon species at the five WRIA 6 sites. The weekly mean catch for juvenile chum, pink, coho, and chinook at each of these sites is summarized in graphs in Appendix A-27.

Table 13. Period of outmigration for juvenile chum, chinook and coho from the Snohomish River at five WRIA 6 nearshore locations, 1987 (Beauchamp et al. 1987).

Site	Beginning of Outmigration			End of Outmigration			Mean Date		
	Chum	Chinook	Coho	Chum	Chinook	Coho	Chum	Chinook	Coho
Whidbey									
Possession	1-Apr	17-May	14-May	7-Jul	31-Jul	13-Jun	19-May	24-Jun	19-May
Sandy Point	11-Apr	16-May	5-May	22-Jun	29-Jul	9-Jun	17-May	22-Jun	23-May
Camano									
Camano SE	6-Apr	26-May	6-May	26-May	29-Jul	27-May	1-May	27-Jun	17-May
Sunny Shores	31-Mar	17-May	6-May	9-Jun	23-Jul	16-Jun	5-May	19-Jun	27-May
Triangle Cove	3-May	18-May	29-Apr	7-Apr	25-Jul	17-Jun	29-May	21-Jun	24-May

## Current Stock Status

### Chinook (*Oncorhynchus tshawytscha*)

In March 1999, Puget Sound chinook stocks were designated as threatened under the federal Endangered Species Act. There are no streams in WRIA 6 of sufficient size or flow to provide spawning habitat for adult chinook. Juveniles may use the lower stream reaches for rearing. The South Whidbey Chapter of the Puget Sound Anglers operates an active chinook net pen project in Langley for on-site release (Gallion 2000).

Juvenile chinook are presumed to use the entire nearshore habitat of WRIA 6 (Map 8). They have been documented along the shoreline at: the north end of Whidbey Island (Hayman, Beamer and McClure 1996), and at the south end of Whidbey and Camano Islands (Beauchamp et al. 1985; RW Beck and Associates 1986; Penttila 1999).

At north Whidbey Island, juvenile chinook counts were high in May, peaked between mid-June and mid-July, and then declined gradually until October (Hayman, Beamer and McClure 1996). The juvenile chinook sampled in this vicinity were assumed to originate from the Skagit River and to include at least three juvenile life history types within the ocean type chinook of that watershed. The first life history type includes emergent fry that migrate directly to the Skagit Bay early in the year. The second type consists of fry that emerge from spawning areas, move quickly downstream to estuarine habitats where they rear for a few weeks prior to moving into the bay. Juvenile chinook of the third life history type spend several months rearing in freshwater, and then bypass the estuary to move directly into marine areas in late spring and early summer.

In the North Puget Sound nearshore study, outmigrating juvenile chinook salmon were found in rocky/kelp habitat from late spring through early fall, in the sand/eelgrass habitat, and less commonly in the cobble habitat (Miller et al. 1977). Juvenile chinook were encountered from mid- to late spring into early fall (Miller et al. 1977).



### Coho (*Oncorhynchus kisutch*)

Puget Sound coho salmon stocks are candidates for listing under the federal Endangered Species Act. *The 1992 Washington State Salmon and Steelhead Stock Inventory* lists one coho stock in WRIA 6 (WDFW and WWTIT 1994). In that document, the “Whidbey Island coho” is shown to occur in Maxwellton Creek on south Whidbey Island. The origin of the stock is stated as unknown, but it is described as being of mixed origin because Skykomish coho have been released into streams in this area.

Coho have been planted on several occasions and by several parties into Maxwellton Creek since at least the late 1970s (Anderson 1999). They were released “off and on” between 1979 and 1989 with no substantiated returns (Bochte and Fitz 1989). During April of each year since 1991, 5th grade students from South Whidbey School District release approximately 1000 coho into Maxwellton Creek. The students raise about 500 coho fry and receive an additional 500 from hatcheries. From 1994 to the present, between 20,000 and 50,000 coho and chum have been raised in remote site incubators and released into the stream.

Coho are also known to occur in Glendale Creek (Base 1999) and Quade Creek (Williams et al. 1975). Whether they are native to the stream is unknown. They may also originate from the nearby Possession Point Bait Company (Gallion 2000).

The WRIA 6 streams that have been identified as having potential for coho habitat include: Cultus Creek, Lone Creek, North Bluff Creek, Swantown Creek, Crescent Creek and an unnamed tributary to Maxwellton Creek on Whidbey Island, and Kristofferson Creek, an unnamed tributary to Kristofferson Creek, and Chapman Creek on Camano Island (Base 1999).

Juvenile coho are presumed to use the entire nearshore habitat for rearing (Map 9). They have been documented at sampling sites: at the north end of Whidbey Island (Hayman, Beamer and McClure 1996), along the shorelines of south Whidbey Island and at south Camano Island (Penttila 1999), and at southeast side of Whidbey and the southeast and east side of Camano (Beauchamp et al. 1985; RW Beck and Associates 1986). At the north Whidbey sampling sites, juvenile coho were counted from early May through June (Hayman, Beamer and McClure 1996). The largest count (249) occurred on May 19 at Ala Spit, representing 84 % of the total coho counted at the north Whidbey nearshore sites, and 65 % of the total juvenile coho counted from all Skagit Bay study sites.

### Chum (*Oncorhynchus keta*)

Puget Sound chum stocks are not currently being considered for listing under the federal Endangered Species Act. *A Catalogue of Washington Streams and Salmon Utilization* (Williams et al. 1975) reported chum to occur in Maxwellton Creek and its largest tributary stream, Quade. Non-native chum in the Maxwellton sub-basin have been planted by the Maxwellton Chums Salmon Adventure and others and have not been documented returning to spawn. Glendale Creek is the only stream in WRIA 6 in which chum have

been documented to use for spawning. The use of Glendale Creek by chum did not occur (in recent history) until 1998 when a large flood blocked the entry to a long, impassable culvert, creating a new stream channel that emptied into the Sound (Ramsey 1999). The origin of the chum using Glendale Creek is unknown. Chum are reported to have historically occurred in Crescent Creek (Klope 1999). Kristofferson Creek, Lone Creek, Swantown Creek, Cultus Creek, Crescent Creek, and Chapman Creek offer potential chum habitat restoration opportunities (Base 1999).

The entire nearshore area of WRIA 6 is presumed to provide rearing habitat for juvenile chum salmon (Map 10). The WDFW has documented more than three decades of juvenile chum use of index areas along Whidbey and Camano Islands as part of the annual marine fry surveys (Hendrick 1999). Chum were the most abundant species documented in 1995 at sampling sites at the north end of Whidbey Island (Hayman, Beamer and McClure 1996). Juvenile chum accounted for nearly 92 % (10,112) of all species of juvenile salmonids counted at Ala Spit and Hoypus Point, and 49 % of the total number of juvenile chum counted in the Skagit Bay study. Juvenile chum were incidentally counted at several nearshore sites along the southern half of Whidbey Island and the south and east shore of Camano Island between 1979 and 1985 as part of the WDFW forage fish surveys (Penttila 1999). Juvenile chum counts at north Whidbey sites were highest in May and dropped significantly after that. June through September as part of forage fish surveys (Penttila 1999). The largest numbers were encountered in June and July.

#### Pink (*Oncorhynchus gorbuscha*)

Puget Sound pink stocks are not currently being considered for listing under the federal Endangered Species Act. Pink salmon are not known to occur in any of the streams in WRIA 6. The streams in WRIA 6 are not of sufficient size or flow to provide freshwater habitat for this species.

All nearshore habitat in WRIA 6 is presumed to provide important rearing habitat for juvenile pink salmon (Map 11). Known use of WRIA 6 nearshore habitat for pink salmon has been documented for more than three decades by the WDFW as part of their annual marine fry surveys (Hendrick 1999). Juvenile pink salmon were incidentally counted at select locations along the west shoreline of the southern half of Whidbey Island in June through September in 1980, the highest numbers occurring in June (Penttila 1999). Juvenile pinks were also documented at nearshore study sites at southeast Whidbey Island and along the east shoreline of Camano Island as part of the Snohomish River outmigration study in 1985 (Beauchamp et al. 1985) and 1986 (RW Beck and Associates 1986).

Data from the 1986 Snohomish River outmigration study suggested a bimodal pattern of abundance with peaks occurring during April 14-18 and May 5-9 (RW Beck and Associates 1986). The largest catches were encountered during the first two weeks of April at southeast Camano Island, Possession Point, and Sandy Point.

### Sockeye (*Oncorhynchus nerka*)

Puget Sound sockeye stocks are not currently being considered for listing under the federal Endangered Species Act. Sockeye salmon do not naturally occur in any freshwater streams in WRIA 6.

Juvenile sockeye are presumed to migrate along the nearshore of WRIA 6 (Map 12). They were documented at two nearshore study sites at the north end of Whidbey Island in 1995 (Hayman, Beamer and McClure 1996). Juvenile sockeye counts at north Whidbey peaked in May (400), June (75), and July (35) (Hayman, Beamer and McClure 1996).

In the mid-1970s north Puget Sound nearshore study, sockeye salmon were infrequently encountered in neretic waters (Miller et al. 1977). This was thought to be a result of a relatively quick migration into deeper waters upon entering salt water. When they were found, it was usually only in northeastern Puget Sound from May through September.

### Bull trout (*Salvelinus confluentus*)

In October 1999, the U. S. Fish and Wildlife Service listed bull trout as threatened under the federal Endangered Species Act. Neither bull trout nor Dolly Varden are known to occur in the fresh waters of WRIA 6.

Native char are presumed to use nearshore habitat in WRIA 6 but only one Dolly Varden is documented in the data sources used in this report. It was counted off of Ala Spit in August 1995 as part of the Skagit River chinook restoration research (Hayman, Beamer and McClure 1996). Bulltrout and coastal cutthroat are reportedly caught by sport fishermen in some nearshore areas of WRIA 6 (LaRock 2000).

### Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*)

The coastal cutthroat trout stocks of Puget Sound are not currently being considered for listing under the federal Endangered Species Act. Coastal cutthroat trout are known to occur in Maxwellton Creek, North Bluff Creek, Glendale Creek, Dugualla Creek and Quade Creek on Whidbey Island, and in Chapman Creek on Camano Island (Base 1999). Cultus Creek is presumed to support cutthroat trout.

Several streams have been identified as having the potential to provide habitat for cutthroat, including: Old Clinton Creek, Deer Creek, Glendale Creek, Cultus Creek, Saratoga Creek, Honeymoon Creek, Swantown Creek, Chapman Creek, Cavalero Creek, Brookhaven Creek, Saratoga Creek, Lone Creek, Kristofferson Creek, and Carp Creek (Base 1999).

Juvenile coastal cutthroat are presumed to use the nearshore habitat of WRIA 6 (Map 13). One coastal cutthroat was documented in the offshore of south Camano Island in July 1983 (Penttila 1999). One unidentified “trout” species was documented in the nearshore habitat off of north Whidbey Island as part of the Skagit River chinook restoration research (Hayman, Beamer and McClure 1996).

### Steelhead (*Oncorhynchus mykiss*)

The steelhead stocks of Puget Sound are not currently being considered for listing under the federal Endangered Species Act. Steelhead do not occur in any streams in WRIA 6. The streams are of insufficient size and flow to provide steelhead habitat. They are presumed to be using the nearshore habitat but no data were located to document this.

### Forage Fish

The WDFW has conducted surveys of Pacific herring (*Clupea harengus pallasii*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) in the intertidal and nearshore habitats of WRIA 6 since 1972 (Penttila 1999). These three species comprise “essential trophic links within nearshore pelagic food webs, connecting zooplankton assemblages with a wide array of predatory species” (Penttila 1999). The locations of some of their annual spawning sites have been mapped and the spawning seasons identified. The spawning needs and location of spawning for these three species make them vulnerable to shoreline development.

The nearshore map (Map 2) included with this report shows only surf smelt and Pacific herring spawning areas, and may be missing additional spawning sites mapped by the WDFW. Some sand lance data is available from WDFW and Island County. Additionally, the Island County Beachwatchers Program now includes sandlance spawning as part of its shoreline inventory.

Pacific herring spawn annually in the Dugwalla Bay-north Skagit Bay region, Holmes Harbor, and Port Susan. Spawning typically occurs in February and March. The herring eggs are normally deposited on beds of native eelgrass (*Zostera marina*) and the red alga (*Gracilariopsis*) in the lower intertidal and shallow sub-tidal zone. In Port Susan, herring spawn is also occasionally found on intertidal gravel-cobble beaches.

WRIA 6 supports one of the larger surf smelt populations in Puget Sound. Surf smelt spawning has historically been known to occur in the vicinity of Utsalady-Camp Grande, south Dugwalla Bay, Oak and Crescent Harbors, Penn Cove, and Cavelero’s Beach on northwest Port Susan. As of 1999, about 74 km of shoreline in WRIA 6 were considered to be surf smelt spawning habitat, comprising 22 % of the total mapped habitat in Washington State (Penttila 1999). In Island County, most surf smelt spawn from April through October. Some spawning may also occur during the winter at a few locations. Smelt eggs are deposited on sand-gravel substrates in the upper intertidal zone during high tides.

As of 1999, about 39 km of shoreline in WRIA 6 have been identified and mapped as sand lance spawning beach, comprising about 18 % of the total known sand lance spawning habitat in Washington State (Penttila 1999). Like the surf smelt, the sand lance in Island County also tend to be “summer” spawners. Sand lance deposit their eggs on upper intertidal sand and gravel substrates during high tides.

## HABITAT LIMITING FACTORS

### Habitat Limiting Factors used by the Washington State Conservation Commission

Loss of Access to Spawning and Rearing Habitat. This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

Freshwater and Tidal Flooding. Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the stream channel and provide storage for flood waters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that provide important spawning habitat, rearing habitat, and refugia for organisms during high streamflows. Along the coastline of Puget Sound, salt marshes and estuaries are also, under natural conditions, exposed to flooding twice a day from tidal waters. The tides flush nutrients into and out of these ecosystems and provide vegetation and organisms with the saline environment they need to survive.

This category includes direct loss of aquatic habitat from human activities in floodplains (such as filling) and disconnection of main channels from floodplains with dikes, levees and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

Channel Conditions and Sediment. This category addresses instream habitat characteristics that are not adequately captured by another category, such as bank stability, pools, and large woody debris. Changes in these characteristics are often symptoms of impacts elsewhere in the watershed, which should also be identified in the appropriate category (sediment, riparian, etc.).

Changes in the inputs of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel instability and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel, and lower the production of benthic invertebrates. This category addresses these and other sediment-related habitat impacts caused by human activities throughout a watershed. This includes increases in sediment input from landslides, roads, agricultural practices, construction activities, and bank erosion; decreases in gravel availability caused by dams and floodplain constrictions; and changes in sediment transport brought about by altered hydrology and reduction of large woody debris.

Riparian Conditions. Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for large woody debris. Riparian impacts include timber harvest,

clearing for agriculture or development, construction of roads, dikes, or other structures, and direct access of livestock to stream channels.

*Water Quality.* Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts in a watershed, such as direct animal access to streams. High concentrations of fecal coliform bacteria may also indicate high concentrations of nutrients that can in turn cause a depletion of dissolved oxygen.

*Water Quantity.* Changes in flow conditions can have a variety of effects on salmonid habitat. Low flows can reduce the availability of summer rearing habitat and contribute to high temperature, low dissolved oxygen, and access problems. High peak flows can scour out or transport sediment into spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, and a variety of land use practices.

*Estuarine and Nearshore Habitat.* This category addresses habitat impacts that are unique to estuarine and nearshore environments.

Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence on fresh water. These areas provide important rearing habitat and an opportunity for transition between fresh and salt water. Impacts include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates and dikes.

Nearshore habitat includes intertidal and shallow subtidal salt water areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, overwater structures, filling, dredging, and alteration of longshore sediment processes.

*Lake Habitat.* Lakes can provide important spawning and rearing habitat for salmonids. This category includes impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, and the application of herbicides to control plant growth.

*Biological Processes.* This category addresses impacts to fish caused by interactions with other species. Some examples include the introduction of exotic (non-native) plants and animals, the role of beaver and beaver dams, and the loss of ocean-derived nutrients due to a reduction in the amount of available salmon carcasses.

## **Whidbey Island Sub-basins**

### Berry (Greenbank Wetland)(54)

*Access.* The tidegate and culvert under North Bluff Road is at least a partial barrier to fish passage and impedes saltwater flows from entering the Greenbank wetland.

*Freshwater and Tidal Flooding.* The tidegate is limiting tidal flows from entering the salt marsh. Currently saltwater only flows into the lower portion of the wetland (on both the east and west side of North Bluff Road), but does not reach the upper wetland (Wahlin 2000). If tidal waters are allowed into the wetland system, landowners along North Bluff Road may require protection from potential flooding

*Channel Conditions and Sediment.* The Greenbank wetland is not connected to a stream system. Additional data are needed to evaluate existing sediment and channel conditions.

*Riparian Conditions.* The western half of the wetland is largely dominated by cattail and bittersweet nightshade (Wahlin 2000). Purple loosestrife is one invasive species reported to be present (Wahlin 2000). There is virtually no buffer around the wetland. Allowing saltwater to enter the wetland would facilitate a transition to saltwater vegetation.

*Water Quality.* No water quality data were located for this report.

*Hydrology.* The Greenbank wetland is located in a closed depression that receives surface runoff from the hills to the north and south. Springs are located within these hills. Water drains from the wetland site along a channel that runs parallel to Shoreline Drive.

*Estuarine and Nearshore Habitat.* Tidal flows are restricted to the lower portion of the salt marsh due to the culvert under North Bluff Road and the tidegate.

*Lake Habitat.* Not applicable.

*Biological Processes.* Purple loosestrife is present in the wetland and is tolerant of saltwater (Wahlin 2000).

### *Recommendations.*

- Replace the culvert underneath North Bluff Road with a structure that will allow for fish passage and tidal flows. Explore the option of removing (or modifying) the tidegate.
- Allow the wetland to naturally restore itself to saltmarsh habitat. Design and implement a vegetation monitoring program.
- Re-vegetate the riparian buffer around the edge of the wetland.

### Brighton (Old Clinton Creek) (116)

*Access.* A tidegate is located at the mouth of Old Clinton Creek and the stream has been tightlined under roads and houses. The creek has also been channeled into a culvert underneath State Route 520 and associated commercial developments.

*Freshwater and Tidal Flooding.* No data were collected for this report.

*Channel Conditions and Sediment.* The channel appears to be stable for most of its length except where it has been tightlined (Kearsley 2000). The stream has been split in its lower reach with a man-made channel that diverts a portion of its flow. Sediment has accumulated at the tightlined culvert system near the mouth of the stream. The 1996 flood event caused the Brighton Beach road to fail, and may have had an adverse impact to the lower portion of the creek system.

*Riparian Conditions.* There appears to be a fairly healthy mature forest buffer along most of the creek's length (Kearsley 2000). There are some impacts from residential and commercial development.

*Water Quality.* No data were located.

*Hydrology.* The headwaters of the stream are formed by springs in a forested area west of Highway 20 (Kearsley 2000).

*Estuarine and Nearshore.* The mouth of the stream and its estuary have been replaced with a housing development built on fill (Kearsley 2000).

*Lake Habitat.* Not applicable.

*Biological Processes.* No data were located.

#### *Recommendations.*

- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of the stream.
- Develop a plan to restore and manage the stream system for coastal cutthroat.

### Crescent (11)

*Access.* The tidegate connecting the estuary to Crescent Harbor was permanently opened in April 1994. The structure and debris rack remain a partial blockage to salmonids. The ditches and dikes prevent salmonid use of much of the marsh system. Additional blockages may exist upstream of the marsh.



*Freshwater and Tidal Flooding.* The presence of the Pioneer Way, the tidegate, and dikes and ditches have greatly modified tidal flows within Crescent Marsh. Pioneer Way functions as a dike. The combination of the tidegate being undersized and the system of dikes and ditches within the estuary prevents much of the site from receiving saltwater inflows. Upstream of the marsh, flooding problems have been observed at Wilson Road and Fakkema Road due to culvert problems (KCM 1998).

*Channel Conditions and Sediment.* Crescent Creek has been ditched and channelized throughout much of its length (KCM 1998; Johnson and Kearsley 1999). In a few instances, the stream has been re-directed into County ditches. Restoration of Crescent Marsh would require that existing ditches be opened to tidal flow. Some channel reconstruction might also be required. Whidbey NAS has explored possible restoration options with an ecologist at the University of Washington (Klope 1999). The data that were located regarding sediment are discussed below under water quality.

*Riparian Conditions.* Most of the riparian vegetation associated with Crescent Creek and Crescent Marsh has been highly altered. The stream channel has been ditched downstream of Fakkema Road and is overgrown with trees and grasses (KCM 1998). Dikes and ditches have contributed to a portion of the salt marsh vegetation transitioning to a freshwater system. Approximately 57 % of the marsh is freshwater, the remainder of the site is covered by saltmarsh vegetation (30 %), open water (3 %), and a sewage lagoon (10 %) (Sheldon and Associates 1999). About 10 % of the marsh is invaded by exotic species, primarily reed canarygrass.

*Water Quality.* Crescent Harbor is one of five sites monitored for water quality and sediment quality as part of the North Whidbey Island Baseline Water Quality Monitoring Program (Herrera Environmental Consultants, Inc. 1995). The monitoring station is located on an intermittent stream at a culvert crossing on Crescent Harbor Road, about 0.8 km east of Auvil Road. The stream is channelized and receives surface runoff from the northwest portion of the sub-basin.

The overall water quality has been judged to be fair. The monitoring results for temperature and dissolved oxygen are presented in Table 14. Temperatures were cool (8.5 °C or less). Dissolved oxygen levels (7.9 mg/l or more) violated the state standard on one occasion (October 31, 1994). Water temperature would be expected to be higher and dissolved oxygen concentrations lower during the summer months. Summer is often the time period when these parameters can be most problematic for fish. Turbidity and nutrient concentrations were low during storm flows. Fecal coliform bacteria exceeded the state standard on two of the three monitoring occasions.

Sediment quality at the Crescent Harbor monitoring site was also judged to be fair. Total petroleum hydrocarbons, copper, and zinc concentrations were elevated in the sediment samples compared to background levels (measured at Deception Pass State Park). Very low levels of DDE were also detected, suggesting historical use of DDT in the sub-basin.

Table 14. Select water quality and streamflow monitoring results, Crescent Creek (ICPW 1997).

	Storm 1	Storm 2	Storm 3
<b>Sample Collection</b>			
Number of samples	3	3	3
Begin date	10/31/94	11/8/94	3/20/95
Begin time	0430	2120	0240
End date	10/31/94	11/9/94	3/20/95
End time	0920	0330	0640
<b>Hydrology</b>			
Mean flow (m <sup>3</sup> /s)	0.001	0.0006	0.016
Peak flow (m <sup>3</sup> /s)	0.001	0.0008	0.018
Total rainfall (cm)	0.69	0.48	0.71
Antecedent dry period (days)	2.5	2.0	6.0
<b>Analytes</b>			
Temperature (C)	8.5	6.8	8.4
Dissolved oxygen (mg/l)	7.9	8.1	9.2

*Hydrology.* Other than the streamflow measurements cited in Table 14, no hydrological data were located for this report. Streamflows may be altered as a result of upstream development. There are extensive wetland systems and springs in this sub-basin (Kearsley 2000).

*Estuarine and Nearshore Habitat.* Pioneer Way, the tidegate and the system of dikes and ditches within the estuary have altered natural tidal flooding processes. The nearshore habitat is presumed to be in good condition (Figure 3).

*Lake Habitat.* Not applicable.

*Biological Processes.* Exotic vegetation within the estuary would presumably be controlled through saltwater inflows.

*Recommendations.*

- Restore tidal flows and improve fish access by replacing (or modifying) the tidegate. Install a conspan or bridge under Pioneer Way.
- Explore the option of closing and removing Pioneer Way.
- Remove the existing dikes and ditches within the estuary and restore distributary channels off of the main channel.
- Allow the marsh to revegetate naturally. Design and implement a vegetation monitoring program.

- Fill the ditch (immediately north) that runs parallel to the road.
- Explore with the Navy and the City of Oak Harbor the feasibility of removing the sewage lagoon, restoring the grade to facilitate restoration of the entire estuary system.
- Explore the possibility of removing the left creek tributary that drains from the Sleeper Road wetlands to the county drainage ditch and unmaintained agricultural channels.
- Identify and protect (through acquisition or easement) the headwaters of Crescent Creek.
- Develop a plan to restore and manage Crescent Creek for the reintroduction of anadromous salmon.
- Provide protection for the riparian buffer through acquisition or conservation easements.

Figure 3. Crescent Harbor shoreline.



### Crockett (31)

*Access.* The original salt marsh is reported to have been separated from saltwater when the roadway servicing Fort Casey was constructed. (Entranco Engineers, Inc. and

Independent Ecological Services 1986). Around 1950, the Drainage District 6 installed two 76-cm culverts with flap gates at the southwest corner of the lake near the Keystone ferry terminal. A pumping station and drainage ditches were also constructed to modify the hydrology of this site. The tidegate was designed to allow water to flow out of Crockett Lake when the lake elevation exceeded tidal elevation. When the tidal elevation surpassed lake elevation, the flow out of the lake would stop and the flap gates shut. The outlet control structure was later abandoned and the facility became inoperable between 1974 and 1983. This tidegate is not functioning and is a barrier to fish passage.

*Freshwater and Tidal Flooding.* Tidal flows are partially prevented from entering Crockett Lake due to a malfunctioning tidegate. Alterations to the spit also limit tidal surges.

Wanamaker Road, located immediately north of Crockett Lake, frequently floods due to inadequate maintenance of the drainage ditches owned by Diking District 6 that drain into Crockett Lake (KCM 1998).

*Channel Conditions and Sediment.* There is no existing information on sediment for the Crockett Sub-basin or for Crockett Lake.

*Riparian Conditions.* The riparian vegetation associated with Crockett Lake and adjacent wetlands is in poor condition due to the alteration of natural tidal flows. Invasive exotic species are also present.

*Water Quality.* Under natural conditions, Crockett Lake is a brackish water wetland complex. The lake salinity varies depending on the relative mix of saltwater and fresh water, and the extent of evaporation. Water samples collected from Crockett Lake in 1973 (when the tide gates were inoperable) had salinity values ranging from 26 to 28 ‰ (Island County 1974). Salinity values were lowest during the fall when precipitation increased freshwater inflow. No current salinity data were located for this report.

In 1972, water samples collected from Crockett Lake by the Army Corps of Engineers had higher nutrient (phosphorus) concentrations than Admiralty Bay. In November 1973, phosphorus in the lake ranged from 0.10 to 0.42 mg/l while phosphorus from saltwater inflow was 0.18 mg/l (Island County 1974). Nitrate in the lake ranged from 1.76 mg/l to 6.16 mg/l compared to 0.44 mg/l from the saltwater inflow. Nutrient levels in the drainage from surrounding areas compared with the phosphorus and nitrate levels measured in the lake.

High water levels in Crockett Lake could contribute to an increase in nutrients within the system and a potential threat to public health if septic system drainfields from low-lying developments flood and contaminate surface and ground waters. There is also a groundwater well southeast of Crockett Lake that serves the Telaker Shores development. Contamination could occur if water levels exceeded the top of the well casing (9.21 ft MLLW) (Entranco Engineers, Inc. and Independent Ecological Services 1986).

The WDOE monitors water quality in Admiralty Inlet at two locations. Samples have been collected monthly since 1988. Water quality at these stations is known to be good and comparable to that of the main basin of Puget Sound. Concentrations of nutrients, chlorophyll a, and fecal coliform bacteria are low, while dissolved oxygen and transparency levels are high. Occasional low dissolved oxygen concentration result from up-welling of deep, low-oxygenated ocean waters in the inlet (WDOE 1994).

*Hydrology.* The surface area of Crockett Lake has been estimated to range from 10 ha (circa 1952) to 202 ha (in 1942 and 1977) (Fakkema and Kingma 1983). A small artificial lake in the southeast corner of the sub-basin is part of the Admirals Cove Development. It has an outlet connecting to Admiralty Bay and a drainage ditch connecting to the wetlands. An intermittent stream and a few drainage ditches drain into Crockett Lake from an area to the north; most of the freshwater inflows occur through surface runoff. Groundwater flows influence the hydrology of the wetlands to the east.

Flooding occurred during the winter months between 1974 and 1983 (Wagner 1983). The tide gates were not operating during this time period; open culverts allowed saltwater inflow during high tides. When the tide gates were not operating, the water surface elevation of Crockett Lake was estimated to stabilize at between 5 and 6 MLLW, under typical tidal cycles (Entranco Engineers, Inc. and Independent Ecological Services 1986). Higher water surface elevations would likely occur when successive high tides increase marine inflow and/or relatively high low tides prevent sufficient discharge from the lake. Flooding could also result from direct precipitation and surface runoff during storm events. The highest water levels were reported on January 14, 1983. This was believed to have been caused primarily by precipitation (Entranco Engineers, Inc. and Independent Ecological Services 1986).

In 1986, Crockett Lake covered about 61 ha and was up to 0.6 m deep (Entranco Engineers, Inc. and Independent Ecological Services 1986). The lake level at that time was reported to be about the same level it was in 1942, prior to the installation of the tidegate. In 1986, the wetlands east of the marsh were connected to Crockett Lake via a network of drainage channels and a 61-cm culvert. In 1986, base surface and groundwater flows for the entire lake system were estimated to be  $0.1 \text{ m}^3/\text{s}$  in the winter and  $0.04 \text{ m}^3/\text{s}$  in the summer (Entranco Engineers, Inc. and Independent Ecological Services 1986). An additional  $0.05 \text{ m}^3/\text{s}$  of saltwater (with the inoperable tidegate) was estimated to be seeping through the dike separating Crockett Lake from Admiralty Bay. In 1987, the Skagit County Superior Court issued a decision (in response to a law suit filed in 1985 by Seattle Pacific University) requiring the Drainage District No. 6 Commissioners to maintain lake levels at specific guidelines (Doody 1990).

*Estuarine and Nearshore Habitat.* Tidal flows into the Crockett wetland system have been altered through a number of factors described above. There are no data on the quality of the nearshore habitat.

*Lake Habitat.* As described above.

*Biological Processes.* Local residents have identified mosquitoes as a problem. Their presence is believed to be associated with the water level in Crockett Lake (Kearsley 2000).

*Recommendations.*

- Acquire privately owned land as it becomes available.
- Initiate a cooperative agreement with existing landowners regarding the restoration of the natural salt marsh habitat.
- Investigate options for replacing or removing the tidegate to increase tidal exchange and restore access to Keystone Harbor. One option is to remove the tidegate and install a bridging structure under Keystone Road to restore the channel to the harbor. A second option is to permanently open the existing tidegate. A second outlet channel might also need to be constructed along the south side of Crockett Lake.

Cultus (118)

*Access.* Fish passage is partially or wholly blocked to Cultus Creek by a tidegate at the north end of the dike (Figure 4). The culverts that have been installed on both sides of Bailey Road also impede fish passage. Upstream of Bailey Road, a private landowner has constructed an earthen dam. Water from upstream drainage flows through a perched pipe in the dam.

Figure 4. Tidegate at the mouth of Cultus Creek.





*Freshwater and Tidal Flooding.* The privately-owned dike and tidegate are preventing tides from entering the estuary.

*Channel Conditions and Sediment.* The channels in the vicinity of the wetland were dredged in 1999 (Wahlin 2000). Where livestock have had direct access to the stream channels within the estuary, the stream channels are likely to be damaged.

*Riparian Conditions.* A riparian survey has not been conducted on Cultus Creek. Natural vegetation within the estuary has been replaced by pasture (Figure 5). Exotic species are also present. The riparian corridor above the estuary is presumed to be in relatively good condition (with some impact from residential development).

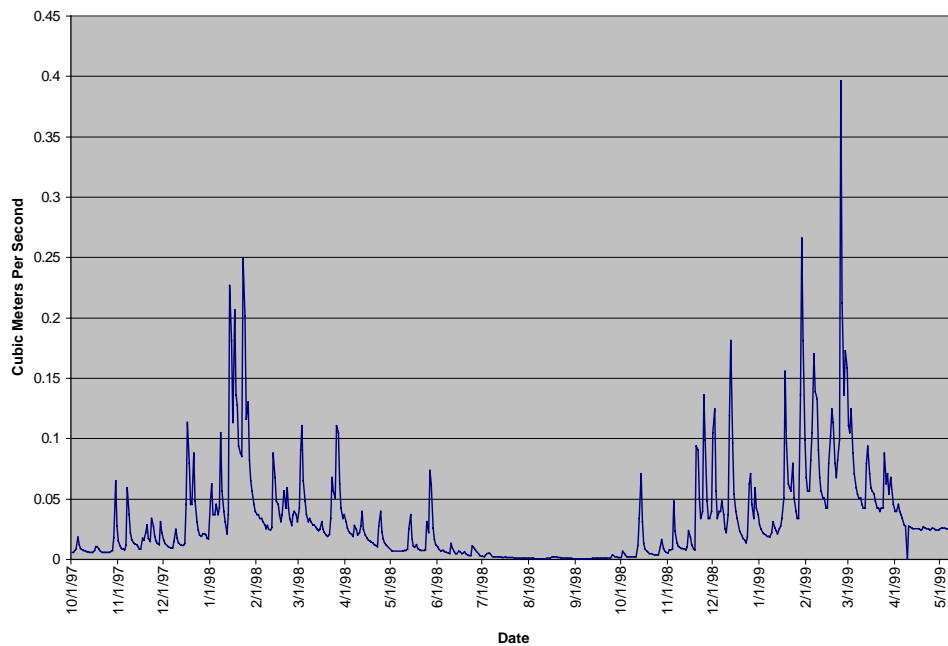
Figure 5. Cultus estuary behind existing dikes.



*Water Quality.* No water quality data were located for this report. Livestock do have direct access to the stream channels in the historic estuary so the potential for high levels of fecal coliform bacteria exist. Septic systems within the Sandy Hook development may also be leaching into Cultus Bay. High nutrient levels may reduce dissolved oxygen conditions. Low flows in the summer months may be contributing to high temperatures and low dissolved oxygen concentrations, especially in the lower stream reaches lacking riparian cover. Salinity values are presumed to be altered.

*Hydrology.* Cultus Creek is one of only two fish-bearing streams in WRIA 6 in which streamflow data were located for this report. The data were recorded from a USGS stream gage on Cultus Creek upstream of the mouth (Sumioka 1999). The gage was installed to collect data for the Island County groundwater recharge study. The hydrograph shown in Figure 6 depicts streamflow from October 1, 1997 through May 11, 1999. During this time period a peak flow of  $0.4 \text{ m}^3/\text{s}$  was recorded on February 24, 1999. Between June 30, 1998 and October 12, 1998, streamflow fell below  $0.003 \text{ m}^3/\text{s}$  for

Figure 6. Cultus Creek streamflow, October 1, 1997 to May 11, 1999 (Sumioka 1999).



all but 9 days, with the lowest flows recorded at  $0.0006 \text{ m}^3/\text{s}$ . The average flow between October 1, 1997 and September 30, 1998 was  $0.02 \text{ m}^3/\text{s}$ . The headwaters of the stream are derived from hillside springs (Kearsley 2000). Wetland systems, like those found downstream of Bailey Road, are also presumed to contribute base flow to the stream.

*Estuarine and Nearshore.* The Cultus estuary has been converted to pasture land through the construction of dikes and the tidegate. The shoreline along Sandy Hook has been heavily modified by residential development and groins (Figure 7). A private harbor has also been constructed east of the sand spit.

The unaltered portion of Cultus Bay is in relatively good condition (Figure 8).

*Lake Habitat.* Not applicable.

*Biological Processes.* Coho are reportedly being raised in net pens in the vicinity of Sandy Hook. Exotic species are present in the historic estuary but would probably be eradicated if saltwater was allowed to enter the site.



Figure 7. Sandy Hook residential development at Cultus Bay.



Figure 8. Cultus Bay at low tide.



*Recommendations.*

- Acquire (or obtain conservation easements) to protect and restore the privately held parcel within the Cultus Bay Estuary.
- Remove the dike and culvert to allow for fish passage and tidal flooding. If access to the home on the spit is required, bridge the dike or provide for an alternate route.
- Design and implement a vegetation monitoring program for the estuary.
- Repair the existing culverts on Bailey Road.
- Remove the private dam above Bailey Road.
- Identify and protect the headwaters of Cultus Creek.
- Provide protection of the riparian stream buffer through acquisition or easement, and explore cooperative restoration partnerships with local landowners.
- Develop a plan to restore and manage Cultus Creek for coastal cutthroat and the reintroduction of anadromous salmon.

Deer (117)

*Access.* Access is the major habitat factor limiting salmonid use of Deer Creek. The mouth of the stream is funneled through an 46-cm culvert underneath Columbia Beach Drive and then across a private parcel (Lot 29) into a 53-cm, 56-m long flume (KCM 1998) (Figure 9). The perched flume discharges from the top of the seawall onto Columbia Beach. Upstream, the Anderson Road Dam blocks all fish passage. If these two barriers were corrected, fish use could potentially extend to Deer Lake.

*Floodplains and Tidal Exchange.* The natural topography of the Deer Sub-basin has precluded the establishment of a salt marsh with fluctuating tidal waters at the mouth of the stream. Flooding from stormwater runoff has been documented to occur at the perched outfall pipe on Columbia Beach Road during high tides (KCM 1998).

*Channel Conditions and Sediment.* The channel conditions are presumed to be in good condition except for the lowermost reach where the stream has been diverted into an underground flume and riparian vegetation is absent.

Figure 9. Flume above mouth of Deer Creek.



*Riparian Conditions.* The Deer Creek riparian corridor is relatively intact throughout most of its length (Figure 10). There have been some limited impacts from residential development.

Figure 10. Deer Creek riparian corridor.



*Water Quality.* Deer Creek is one of six sites monitored for water quality and sediment quality as part of the Central/South Whidbey Watershed Baseline Water Quality Monitoring Program (Parvin 1998). The monitoring station is located on Deer Creek on the east side of Columbia Beach Road. In general, the water quality at the Deer station

was judged to be “excellent” except for fecal coliform bacteria at base flow. Sediment contamination does not appear to be a problem.

The monitoring results for temperature and dissolved oxygen are presented in Table 15.

Stream temperatures were cool (10.0 °C or less). Dissolved oxygen concentration (7.7 mg/l) fell below the state standard on February 26, 1997. High levels of fecal coliform bacteria (300/100 ml) were detected during base flow monitoring on August 6, 1997. Water temperature would be expected to be higher and dissolved oxygen concentrations lower during the summer months. Summer is often the time period when these parameters can be most problematic for fish.

Table 15. Select water quality and streamflow monitoring results, Deer Creek (Parvin 1998).

	Event 1	Event 2	Event 3
<b>Sample Collection</b>			
Number of samples	3	3	3
Begin date	2/26/97	3/12/97	3/26/97
Begin time	1150	1127	1040
End date	2/26/97	3/12/97	3/26/97
End time	1310	1240	1152
<b>Hydrology</b>			
Mean flow (m <sup>3</sup> /s)	0.05	0.06	0.06
Peak flow (m <sup>3</sup> /s)	0.05	0.06	0.06
Total rainfall (cm)	0.18	0.3	0.00
Antecedent dry period (days)	0.00	0.17	0.00
<b>Analytes</b>			
Temperature (C)	7.0	6.3	10.0
Dissolved oxygen (mg/l)	7.7	12.4	11.4

*Hydrology.* Some streamflow data were collected as part of the water quality monitoring program and are shown in Table 15. The headwaters of the stream are formed by the lake and hillside springs.

*Estuarine and Nearshore.* There is no estuary associated with this drainage. The nearshore habitat has been heavily modified from residential development (Figure 11).

*Lake Habitat.* Deer Lake forms the headwaters of this sub-basin. Salmonids could potentially use the lake as habitat. More information is needed.

*Biological Processes.* Exotic species are present in the riparian corridor where land use modification has occurred. The impact of stocked trout in Deer Lake is unknown.

Figure 11: Deer Creek nearshore and mouth.



*Recommendations.*

- Acquire the property upon which the flume is sited. Remove the flume and perched culvert at Columbia Beach to re-establish the stream channel at the mouth of the creek.
- Provide for fish passage at Anderson Dam.
- Remove exotic vegetation where present and revegetate the riparian corridor.
- Identify and protect (through acquisition or easement) the headwaters of Deer Creek.
- If fish passage is obtainable, develop a plan to restore and manage Deer Creek for coastal cutthroat and anadromous salmon.
- Provide protection for the riparian buffer through acquisition or conservation easements, and develop partnerships with landowners for riparian restoration projects.

## Dugualla (7)

*Access.* Access is the major habitat factor limiting salmonid use of Dugualla Creek. The tidegate prevents blocks fish passage

*Freshwater and Tidal Flooding.* Tidal flows have been altered by the tidegate and the dike under the road at the mouth of Dugualla Creek.

*Channel Conditions and Sediment.* No data were located for this report.

*Riparian Conditions.* The Dugualla Creek riparian corridor has been highly modified. Riparian vegetation is totally absent from the historic estuary as the site is currently being farmed. No data were located on upstream riparian conditions, but it is also believed to have been modified (Kearsley 2000).

*Water Quality.* No water quality data were located for this report. A Superfund site is located on the Navy base. Most stormwater from Ault Field is routed into this drainage and is presumed to carry assorted urban pollutants. Agricultural is active in lower drainage and contributes runoff to Dugualla Creek. Nearby marine waters host an active offshore dredge disposal site (KCM 1998). Salinity values are unknown.

*Hydrology.* No streamflow data were located for this report. The headwaters are presumed to form from hillside springs (Kearsley 2000).

*Estuarine and Nearshore Habitat.* The Dugualla estuary was historically one of the largest estuarine systems in WRIA 6, extending west of what is now State Route 20. It has been heavily modified, but has high potential for restoration.

*Lake Habitat.* No information was located concerning Dugualla Lake.

*Biological Processes.* No information was located.

### *Recommendations.*

- Conduct a feasibility study on the restoration of the Dugualla stream and estuarine system. This study should include removing or modifying the tidegate to allow for fish passage and restoration of the historic channel.
- Identify and protect the headwaters of Dugualla Creek.
- If fish passage is obtainable, develop a plan to restore and manage Dugualla Creek for coastal cutthroat and anadromous salmonids.
- Provide protection for the riparian buffer, and initiate partnerships with local landowners to conduct riparian restoration projects.

## Glendale (119)

*Access.* Access is the major factor limiting fish production in Glendale Creek. Five fish passage problems have been identified to date. The most significant project is just upstream of the mouth of Glendale Creek. For more than 30 years, the lower portion of Glendale Creek flowed through a 76-cm pipe adjacent to Glendale Road (Sheldon & Associates, Inc. 1999b). In the winter of 1995-96, stormflows caused the culvert to become blocked at the inlet. As a result, the stream bypassed the culvert and flowed unconfined down Glendale Road and adjacent properties. The stream cut around the foundation of the tightlined culvert removing all of the fill. The force of the flood eventually caused the entire system to fail and blew out the culvert. This system failure caused extensive damage to private driveways, utilities, and roads. The damaged culvert was removed. The new channel, located in the Glendale Road right-of-way, has become deeply incised with a steep gradient, little gravel, and no significant vegetative cover. Temporary culverts are allowing residents of private properties to access to their driveways.

There is another 122-cm culvert at Glendale Road which is a barrier to fish migration due to its length, a steep gradient, and the fact that it is perched about 0.5 m above the stream's water surface (Aquatic Resource Consultants 1997; KCM 1998). Other culverts are located further upstream at Frogwater Road and Old Wagon Road (Wahlin 2000).

In addition to these fish barriers, there are two dam structures located in the upper portion of the drainage. The dam on the upper right tributary is used to maintain a private pond for swimming. The second dam is located on the upper mainstem. Its origin and purpose are unknown (Kearsley 2000).

*Floodplains and Tidal Exchange.* The natural topography of the Glendale Sub-basin has precluded the establishment of a salt marsh with fluctuating tidal waters at the mouth of the stream. Flooding from Glendale Creek has been documented to occur at Glendale Road as a result of culvert problems (KCM 1998).

*Channel Conditions and Sediment.* Land use in the headwaters of Glendale Creek has created erosion and sedimentation problems that could prevent salmon eggs in downstream redds from hatching. Several slopes have failed subsequent to the December 1996 storm (KCM 1998). The soils in Glendale Canyon are naturally prone to erosion that can cause further impacts to the stream channel (Kearsley 2000). The channels in the upper watershed are stable and support extensive wetland systems.

*Riparian Conditions.* The steep gradient of the Glendale Creek drainage has limited human impact to the riparian buffer adjacent to the creek. There is evidence that past logging practices have converted the native vegetation to a relatively young forest dominated by red alder and salmon berry (Johnson and Kearsley 1999). Today only a few conifers exist and they are mostly located on the upper slopes of the canyon at a distance too far to contribute large woody debris to the stream system.

The riparian area along the lower portion of the stream consists of residential lawns, invasive exotic species, including reed canarygrass and Japanese knotweed, and pavement. Removal and control of Japanese knotweed and other exotic vegetation is important to restoring the health of this stream system.

*Water Quality.* No water quality data were located for this report.

*Hydrology.* No streamflow data were located for this report. The wetland systems and hillside springs form the headwaters of this stream. The creek is presumed to be perennial throughout its length. There is concern that private water systems may be contributing to low flows in the creek (Kearsley 2000).

*Estuarine and Nearshore Habitat.* There are no estuary or salt marsh habitats associated with this stream due to the natural topography of the drainage. The nearshore habitat is modified from residential development.

*Lake Habitat.* Not applicable.

*Biological Processes.* Exotic species are present where land use modification has occurred. Beavers were present in the stream system until two years ago (Wahlin 2000). Local residents do not know why the beavers have disappeared.

*Recommendations.*

- Abandon Glendale Road and acquire for public ownership.
- Replace the deteriorating outfall that drains to Possession Sound. Construct a fish passage channel through the Glendale community and revegetate the riparian buffer with native vegetation.
- Replace the temporary culvert at Humphrey Road with an arched culvert.
- Replace the culvert at the lower section of Glendale Road to allow for fish passage.
- Replace the Holst/Glendale culvert with a fish passage culvert.
- Modify or remove the existing dams to allow for fish passage.
- Identify and protect the headwaters of Glendale Creek.
- Encourage private landowners to replace culverts that pose fish passage problems.
- Develop a plan to restore and manage Glendale Creek for coastal cutthroat and anadromous salmon.
- Provide protection for the riparian buffer through acquisition or easements, and for partnerships with local landowners to conduct riparian restoration projects.



- Replace a failing private drainage system on the left lower tributary to minimize impacts to hillside seepage.
- Remove the illegal dumpsite in the canyon.

Hancock (56)

*Access.* There are no access issues.

*Freshwater and Tidal Flooding.* Tidal flows are not impeded.

*Channel Conditions and Sediment.* No data, but presumably not an issue.

*Riparian Conditions.* Presumed to be in good condition.

*Water Quality.* No data were located, but the water quality is presumed to be good.

*Hydrology.* No hydrology data were located, but the hydrological conditions are presumed to be functioning.

*Estuarine and Nearshore Habitat.* The estuary and nearshore habitats are presumed to be in good condition as the site is formally protected.

*Lake Habitat.* Not applicable.

*Biological Processes.* *Spartina* is present at Lake Hancock but is being routinely monitored and controlled by Whidbey NAS, the County Noxious Weed Board, and WDFW.

Figure 12 Lake Hancock.



*Recommendations.*

- Lake Hancock is the best remaining example of a salt marsh ecosystem in WRIA 6 (Figure 12). This ecosystem could be established as a control site for future estuary restoration and monitoring efforts at other locations in WRIA 6.0

Harrington (30)

*Access.* Presumed to not be an issue, although reported changes in the channel configuration may be related to nearshore development impacts associated with the surrounding residential community.

*Freshwater and Tidal Flooding.* Presumed to not be an issue at this time, but more investigation is warranted.

*Channel Conditions and Sediment.* A few local residents have reported recent changes in the configuration of the channel connecting Harrington Lagoon to Saratoga Passage. This may be a result of land use modifications to the nearshore environment within the local vicinity.

*Riparian Conditions.* This site lacks a sufficient buffer from adjacent residential development. Some exotic vegetation is also present around the perimeter.

*Water Quality.* No data were located, but water quality is presumed to be good. Fecal coliform bacteria could be leaching from nearby septic systems.

*Hydrology.* Harrington Lagoon receives freshwater from surface runoff. There does not appear to be a problem.

*Estuarine and Nearshore Habitat.* The estuary appears to be functioning well, but the nearshore environment is relatively developed, and being modified by local landowners. This may be contributing to a change in the configuration of the channel.

*Lake Habitat.* Not applicable.

*Biological Processes.* Some exotic vegetation is present around the perimeter of the site.

*Recommendations.*

- Investigate options for acquisition and conservation easements.
- Revegetate the riparian buffer.
- Conduct a time-series analysis of the channel configuration and sedimentation in relation to past nearshore development.

### Holmes Harbor (97)

*Access.* Access to the small salt marsh at the south end of Holmes Harbor is blocked by a tidegate. A dam blocks Honeymoon Creek.

*Freshwater and Tidal Flooding.* At the south end of Holmes Harbor, frequent flooding is occurs adjacent to and south of Shoreview Avenue (KCM 1998). This is caused by several factors. Stormwater runoff naturally drains to the low elevation wetland south of Shoreview Avenue and west of Woodard Road, and is prevented from draining into Holmes Harbor during high tides. The 30-cm culvert located at the northwest side of this wetland under Shoreview Avenue is undersized. Flooding is also a problem to the east of this area (KCM 1998). High tides can cause backwater effects at the tidegate draining to Holmes Harbor. Stormwater is funneled from Steward Road, a ditch between Steward and Myrtle Avenue, and Washington Drive into an open ditch and 61-cm outfall between Washington Drive and Holmes Harbor.

*Sediment and Channel Conditions.* No data were located for this report.

*Riparian Conditions.* No data were located for this report.

*Water Quality.* Holmes Harbor is one of the several Puget Sound marine areas that has been monitored (during the 1995-96 sampling season) as part of the Washington Department of Ecology's Marine Waters Monitoring Program (Newton et al. 1998). The habitat quality of marine waters are characterized by analyzing the stratification of the water column (the layering of the water according to temperature and salinity changes) and by measuring dissolved oxygen, turbidity, and the availability of sunlight below the water surface. Holmes Harbor was found to exhibit persistent stratification. Stratification will affect the distribution of toxics and other biological stressors, such as low dissolved oxygen concentrations.

Holmes Harbor shows strong sensitivity to low dissolved oxygen. Between October 1995 and September 1996, the minimum dissolved oxygen concentrations fell below 5 mg/l during seven of the monthly sampling occasions. Some fish species are stressed by environmental conditions when dissolved oxygen concentrations fall below 5 mg/l (Kramer 1987; Whitmore et al. 1960), while others may not exhibit stress at 2 mg/l (Pihl et al. 1992). When oxygen concentrations drop below 3 mg/l, near hypoxic conditions occur. Continuous or intermittent hypoxic conditions may result in a shift in species composition, a decrease in population numbers and species diversity, a disruption of predator-prey relationships, and a shift in trophic pathways (Newton et al. 1998). The combined effects may result in reduced availability and harvest of marine resources. There is no site-specific information concerning the impact of stratification or low dissolved oxygen concentrations on salmonids in Holmes Harbor.

The WDOE Marine Waters Monitoring program recommends that human activities that could stimulate plankton production, decrease circulation, or increase oxygen demand be

carefully evaluated in the vicinity of Holmes Harbor (Newton et al. 1998). The low DO concentrations are believed to be resulting from natural conditions.

*Hydrology.* A dam modifies the hydrology of Honeymoon Creek. No additional information was located for this report.

*Estuarine and Nearshore Habitat.* The salt marsh at the end of the Harbor needs further field investigation. No nearshore data were located.

*Lake Habitat.* Not applicable.

*Biological Processes.* No data were located.

*Recommendations.*

- Honeymoon Creek and the salt marsh at the end of Holmes Harbor require further field analysis. Access is an issue at both locations.
- Identify and protect the stream headwaters.
- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- If fish passage is obtainable, develop a plan to restore and manage the creek system for salmon.

#### Houston (North Bluff Creek) (45)

*Access.* The North Bluff Road culvert at the mouth of North Bluff Creek is believed to be blocking anadromous fish passage (Johnson and Kearsley 1999).

*Floodplains and Tidal Exchange.* The topography of the Houston Sub-basin has precluded the establishment of a salt marsh with fluctuating tidal waters at the mouth of the stream. Flooding from Houston Creek has been documented to occur at North Bluff Road as a result of culvert problems (KCM 1998).

*Channel Conditions and Sediment.* Channel conditions have not been evaluated but are presumed to be intact because the riparian zone is in good condition.

*Riparian Conditions.* The riparian habitat throughout much of the stream's reach is dominated by mature conifers, and has only marginal impacts from development (Johnson and Kearsley 1999).

*Water Quality.* No water quality data were located for North Bluff Creek.

*Hydrology.* No streamflow data were located for North Bluff Creek.

*Estuarine and Nearshore Habitat.* More information is needed concerning the condition of nearshore habitat.

*Lake Habitat.* Not applicable.

*Biological Processes.* Not applicable.

*Recommendations.*

- Conduct further analysis of the culvert at the mouth of stream and replace if fish passage is a problem.
- Install a stream gage to gather data on annual streamflow.
- Investigate options for protection of the riparian corridor through acquisition or conservation easements.

#### Langley (100)

*Access.* The outfall to Brookhaven Creek is perched. Further field investigation is needed.

*Freshwater and Tidal Flooding.* No data were located.

*Channel Conditions and Sediment.* The Brookhaven Creek channel is fairly stable throughout most of its upper and middle reach (Kearsley 2000). Residential development has impacted some of the reaches. A portion of this stream has been diverted north to allow for the development of a sports field at the South Whidbey Schools. The lower reach is completely tightlined under the City of Langley.

*Riparian Conditions.* The upper reaches of Brookhaven Creek are in native vegetation with fairly substantial buffers (Kearsley 2000). The middle reaches of the stream still have some native vegetation but have been impacted by residential development. A portion of the stream runs through a park in the town of Langley. A dam may be present to create a pond in this location. The creek flows for a short stretch through a highly impacted buffer in the commercial portion of Langley before it is tightlined to Puget Sound.

*Water Quality.* Brookhaven Creek is one of six sites monitored for water quality and sediment quality as part of the Central/South Whidbey Watershed Baseline Water Quality Monitoring Program (Parvin 1998). The monitoring station is located at the seawall culvert outlet at the north end of Anthes Street. In general, the water quality at the Langley station was judged to be “excellent” except for fecal coliform bacteria at base flow, and sediment contamination does not appear to be a problem.

The monitoring results for temperature and dissolved oxygen are presented in Table 16.

Table 16. Select water quality and streamflow monitoring results, Brookhaven Creek (Parvin 1998).

	Event 1	Event 2	Event 3
Sample Collection			
Number of samples	3	3	3
Begin date	2/26/97	3/12/97	3/26/97
Begin time	1346	1352	1219
End date	2/26/97	3/12/97	3/26/97
End time	1505	1456	1330
Hydrology			
Mean flow (m <sup>3</sup> /s)	0.01	0.04	0.02
Peak flow (m <sup>3</sup> /s)	0.01	0.05	0.02
Total rainfall (cm)	0.13	trace	1.80
Antecedent dry period (days)	0.00	0.28	0.00
Analytes			
Temperature (C)	9.0	8.1	10.5
Dissolved oxygen (mg/l)	7.7	11.4	10.9

Stream temperatures were cool (10.5 °C or less). Dissolved oxygen concentration (7.7 mg/l) fell below the state standard on February 26, 1997. Water temperature would be expected to be higher and dissolved oxygen concentrations lower during the summer months. Summer is often the time period when these parameters can be most problematic for fish.

Salmon fry reared in the creek have shown to be an immediate indicator of toxic contaminants (KCM 1998).

*Hydrology.* Some streamflow data were collected as part of the water quality monitoring program (Table 16). Hillside springs form the headwaters. Historical evidence indicates that Brookhaven Creek was once a year-round source of drinking water for the Town of Langley. The municipal wells for Langley are now located in the upper portion of the watershed.

*Estuarine and Nearshore Habitat.* A field inventory is warranted for the nearshore environment.

*Lake Habitat.* Not applicable.

*Biological Processes.* No data were located.

### *Recommendations.*

- Identify and protect the headwaters of Brookhaven Creek through acquisition or conservation easements.
- Reconstruct and revegetate the Brookhaven stream channel in the vicinity of the sports field.
- Investigate options for providing fish passage at the sea wall. If fish passage is obtainable, develop an action plan for restoring and managing Brookhaven Creek for salmonids.
- Provide protection for the riparian buffer through acquisition or conservation easements, and investigate partnerships with local landowners for riparian restoration projects.
- Investigate the potential for salmonid use of Saratoga Creek.

### Maxwelton (108)

*Access.* Access is a major factor affecting fish production in the Maxwelton estuary and stream system. There are 11 culverts on the mainstem of Maxwelton Creek between the tidegates and Miller Lake (Barnes 2000). At least six fish passage problems have been identified thus far as part of the County creek and culvert inventories.

The tidegate at the mouth of the stream, operated by the Diking District, is the most serious problem (Figure 13). The construction date of the original tidegate is unknown. A second 152-cm concrete tidegate was installed in 1960 and relocated to the south to allow for the construction of a house (Bochte and Fitz 1989). It was approved for renovation in 1989 and replaced a year later (Base 1997; Anderson 1999). The WDF (now WDFW) “highly recommended” that tidegates be actively managed between October 15 and January 15 to allow an inflow of saltwater into the marsh during rising tides and allow salmon to pass through the structure. Despite these improvements, fish passage is still a serious problem.

At least five culverts also pose access issues. Four of these culverts were constructed and are maintained by Island County. These include a pair of culverts (76-cm and a perched 91-cm) French Road, a 76-cm perched culvert at Erikson Road, a 76-cm culvert at Maxwelton Road, and a 122-cm culvert at Ewing Road (KCM 1998). The privately owned culvert at Coyote Lane also poses a problem. Six additional privately owned

Figure 13. Tidegate at mouth of Maxwellton Creek.



culverts are located at Carriage Court (2 new 153-cm), at Daisy Lane (91-cm), on the “Arnold property” (92-cm), and just south of Miller Lake (92-cm). The culverts at Daisy Lane and Miller Lake are favored by beavers for building dams.

There are also at least 25 culverts on the major tributaries of Maxwellton Creek (Barnes 2000). These range in size from 153 cm (the new culvert under Maxwellton Creek near Midvale) down to 30 cm, and many are perched. Five of these culverts are on County roads.

*Freshwater and Tidal Flooding.* The tide gate is impeding tidal waters from entering the Maxwellton marsh. Maxwellton Road is also functioning as a dike. Some saltwater does leak in during high tides. However, the marsh vegetation is dominated by freshwater species. The marsh is presumably not providing an estuarine transition zone between freshwater and saltwater bodies that is beneficial to salmonids.

Flooding has been documented to occur in several locations on Maxwellton Creek as a result of inadequate conveyance and poorly installed culverts (KCM 1998). Some residents are reported to also be experiencing flooding problems in connection with beaver dams.

*Channel Conditions and Sediment.* Maxwellton Creek is channelized throughout its lower reaches and in other portions where agricultural practices predominate (Kearsley 2000). The mainstem channel has been modified from Daisy Lane north to Miller Lake, and for most of the section downstream of French Road (Barnes 2000). Residential development has also impacted channel stability though the removal of the native plant buffers. Some sections of the stream have not been altered and remain stable. Some of these protected areas have extensive gravel spawning areas. The 1996 flood caused some damage to the mainstem channel in areas where private culverts and road fill were damaged and flood scouring occurred.



Mud and silt may be accumulating in the marsh in the absence of tidal flows that would naturally flush the marsh habitat. Livestock have direct access to the stream and streambanks in some locations and this often leads to erosion and sediment problems.

A private dam has been constructed for esthetic purposes on the upper left tributary that drains to Miller Lake.

*Riparian Conditions.* The riparian habitat is a mosaic reflective of the mixed land uses in the sub-basin (Kearsley 2000). Agriculturally dominated areas tend to have pasture to the creek edge (Figure 14). Some have small hedgerow buffers of mixed vegetation. Residential areas vary in their treatment of the riparian buffer. Many landowners maintain a manicured buffer. Others have a mixture of trees and cleared underbrush or a wild buffer of invasive species. A few have maintained an extensive native buffer or preservation area. Many areas of the sub-basin remain undeveloped and have a mixed

Figure 14 Modified riparian area along Maxwellton Creek.



forest stand. Some of these areas are reclaimed agricultural homesteads that are predominantly red alder and salmonberry. Mature conifer stands comprise only about 10% to 15% of the riparian buffer in the drainage.

*Water Quality.* Maxwellton Creek is one of six sites monitored for water quality and sediment quality as part of the Central/South Whidbey Watershed Baseline Water Quality Monitoring Program (Parvin 1998). The monitoring station is located on Maxwellton Creek at the Maxwellton Salmon Adventure Outdoor Classroom. In general, the water quality at the Maxwellton station was judged to be “very good” except for fecal coliform bacteria. Sediment contamination does not appear to be a problem.

The monitoring results for temperature and dissolved oxygen are presented in Table 17.

Stream temperatures were cool (10.0 °C or less), but the state standard (16 °C) was exceeded during a base flow measurement on August 6, 1997. Dissolved oxygen

concentration (7.0 mg/l) fell below the state standard on February 26, 1997. High levels of fecal coliform bacteria (240/100 ml) were detected on March 12, 1997. Total suspended solids were highest at this station during base flow. Water temperature would be expected to be higher and dissolved oxygen concentrations lower during the summer months. Summer is often the time period when these parameters can be most problematic for fish.

Additional water quality data have been collected by a local resident (Barnes 2000) but were not evaluated for this report.

*Hydrology.* Some streamflow data were collected as part of the water quality monitoring study (Table 17). Additional data were also collected by a local resident at the culvert on Erikson Road between November 1998 and December 1999 (Barnes 1999).

Table 17. Select water quality and streamflow monitoring results, Maxwellton Creek (Parvin 1998).

	Event 1	Event 2	Event 3
<b>Sample Collection</b>			
Number of samples	3	3	3
Begin date	2/26/97	3/12/97	3/26/97
Begin time	1040	0925	0903
End date	2/26/97	3/12/97	3/26/97
End time	1140	1050	1014
<b>Hydrology</b>			
Mean flow (m <sup>3</sup> /s)	0.09	0.01	0.18
Peak flow (m <sup>3</sup> /s)	0.11	0.12	0.18
Total rainfall (cm)	0.18	0.3	0
Antecedent dry period (days)	0.00	0.17	0.0
<b>Analytes</b>			
Temperature (C)	6.5	6.5	10.0
Dissolved oxygen (mg/l)	7.0	11.4	10.1

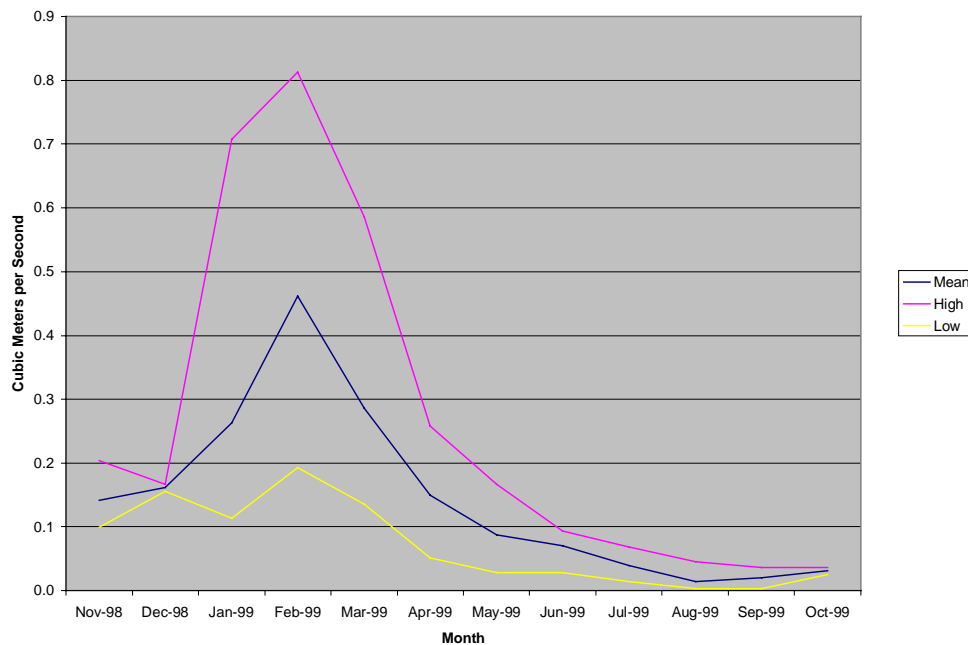
Flow rates were measured by timing the float rate through the culvert (prior to April 21, 1999) and by a flow meter (after April 21, 1999). No data were recorded during flood events so peak flows are unknown.

The data are approximated in some cases and incomplete for the full monitoring period (183 of 365 possible days), but the information does provide a relative picture of the mean monthly, mean annual (0.14 m<sup>3</sup>/s), highest (0.81 m<sup>3</sup>/s) and lowest (0.003 m<sup>3</sup>/s) flows of Maxwellton Creek (Figure 15).

Mean monthly streamflows were highest between January and March, ranging between 0.26 m<sup>3</sup>/s (January) and 0.46 m<sup>3</sup>/s (March). Mean monthly streamflows were measured at 0.04 m<sup>3</sup>/s or less from July through October. The lowest daily flows were recorded in

August and September, measuring only 0.003 m<sup>3</sup>/s. On several occasions in the recent past, portions of the mainstem between Ewing Road and French Road have dried up for several days during late summer or early fall (Barnes 2000). During that time, water was confined to isolated shallow ponds within the stream channel. Agriculture withdrawals for irrigation and well discharges may be impacting streamflows during low flow months (Kearsley 2000).

Figure 15. Maxwellton Creek streamflow, November 1998 through October 1999 (Barnes 1999).



The headwaters of the stream are formed by Miller Lake, wetland systems, and hillside springs.

*Estuarine and Nearshore Habitat.* The Maxwellton estuary has been highly modified as a result of agricultural activities and the construction of Maxwellton Road. Saltwater inflow has been greatly impeded to facilitate farming and protect residential homes in the floodplain. The area has been ditched and drained. The nearshore has been developed for residential land uses.

*Lake Habitat.* Miller Lake contributes headwaters to Maxwellton Creek. The entire shoreline of the 5.8-ha lake is owned by one private landowner. The land has been used as pasture for cattle and horses (Barnes 2000). The minimum lake level is maintained by a 0.9-m culvert. Beavers use this site for building dams and this may be affecting lake levels and streamflow downstream of the site.

The water quality of the lake has not been tested as part of the WDOE Lake Water Quality Assessment Program. A local resident who has been monitoring temperature and dissolved oxygen concentrations at select locations along Miller Creek reports that the water temperature of the lake can be warm during the day in the summer.

The WDFW does not stock trout or other fish in the lake. No other information was located to determine whether private fish stocking has occurred.

*Biological Processes.* The impact of beavers on private property and salmon productivity in the Maxwellton Creek drainage is a controversial topic. A local resident reports that during the summer of 1999, seven beaver dams were located on Miller Creek between the Outdoor Classroom and Miller Lake (Barnes 2000). Some of these dams are reported to be contributing to flooding on private property (Fox 2000). Beaver activity at the outlet of Miller Lake caused an increase in the surface area of the lake last summer, and a concomitant loss of some trees along the shoreline (Barnes 2000). The blockage of the lake outlet may be contributing to low stream flows during the summer months. Beaver activity is believed to be increasing.

*Recommendations.*

- Investigate acquisition or easement options with the Diking District and landowners that own land occupying the historic estuary site and adjacent buffer area.
- Remove the tidegate and reconstruct the channel at the mouth of the stream. Bridge the channel to allow vehicles continued use of Maxwellton Road.
- Restore historic channel configurations in ditched areas and distributary channels in the estuary.
- Replace the culverts at Ewing Road, under Maxwellton Road north of Erikson Road, and under French Road with arch or box culverts to allow for fish passage.
- Vacate Erikson Road, remove the damaged culvert, and construct a pedestrian walkway over the stream.
- Enter into cooperative agreements with private property owners to replace culverts that are barriers to fish passage.
- Initiate a study of historic and current beaver activity in the Maxwellton drainage, and potential impacts on salmonid productivity.
- Encourage and aid private landowners to improve culverts that pose fish passage problems.
- Develop and implement a seasonal survey of fry that have been planted in the creek.

- Construct a boardwalk trail at the headwaters of Quade Creek to protect the wetland headwaters from impacts by hikers.
- Provide protection for the riparian buffer by acquisition or conservation easements, and establish partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of Maxwellton Creek through acquisition or easements.
- Develop a plan to restore and manage the stream system for coastal cutthroat and anadromous salmon.
- Rehabilitate the eelgrass beds and nearshore habitat.

#### Penn Cove (Grasser's Lagoon and Kennedy Lagoon)(18)

*Access.* The tidegate at the entrance to Kennedy Lagoon appears to at least partially block fish passage (Figure 16). Access is not an issue at Grasser's Lagoon.

Figure 16. Tidegate at Kennedy Lagoon.



*Freshwater and Tidal Flooding.* Tides regularly flow into Grasser's Lagoon.

*Channel Conditions and Sediment.* There does not appear to be a sediment problem associated with the lagoons or with Penn Cove.

*Riparian Conditions.* There is virtually no riparian buffer separating Grasser's Lagoon from the surrounding roads. The riparian habitat at Kennedy Lagoon has also been removed or modified in the vicinity of private residences (Figure 17).

*Water Quality.* No water quality data were located for Grasser's Lagoon or Kennedy Lagoon. Potential water quality degradation may result from nonpoint runoff from the surrounding residential properties and from the roadways.

Penn Cove is one of several Puget Sound marine areas monitored as part of the Washington Department of Ecology's Marine Waters Monitoring Program (Newton et al. 1998). The habitat quality of marine waters are characterized by analyzing the stratification of the water column (the layering of the water according to temperature and salinity changes) and by measuring dissolved oxygen, turbidity, and the availability of sunlight below the water surface. Penn Cove was found to exhibit persistent stratification.

Figure 17. Kennedy Lagoon.



Stratification will affect the distribution of toxics and other biological stressors, such as low dissolved oxygen concentrations.

During the 1993-94 monitoring season, there were three months when dissolved oxygen concentrations fell below 5 mg/l, and one month (October 1993) of nearly anoxic conditions. Some fish species are stressed by environmental conditions when dissolved oxygen concentrations fall below 5 mg/l (Kramer 1987; Whitmore et al. 1960), while others may not exhibit stress at 2 mg/l (Pihl et al. 1992). Between October 1995 and September 1996, low DO concentrations were observed more frequently, and fell below 3 mg/l in November 1995 and September 1996. When oxygen concentrations drop below 3 mg/l, near hypoxic conditions occur. Continuous or intermittent hypoxic conditions may result in a shift in species composition, a decrease in population numbers and species diversity, a disruption of predator-prey relationships, and a shift in trophic pathways (Newton et al. 1998). The combined effects may result in reduced availability and



harvest of marine resources. There is no site-specific information concerning the impact of stratification or low dissolved oxygen concentrations on salmonids in Penn Cove.

The WDOE Marine Waters Monitoring program recommends that human activities that could stimulate plankton production, decrease circulation, or increase oxygen demand be carefully evaluated in the vicinity of Penn Cove (Newton et al. 1998). The low DO concentrations are believed to be resulting from natural conditions.

*Hydrology.* Grasser's Lagoon and Kennedy Lagoon receive freshwater from surface runoff.

*Estuarine and Nearshore Habitat.* Grasser's Lagoon appears to be functioning relatively well, though it lacks a riparian buffer (Figure 18). The shoreline of Kennedy Lagoon is more modified and tidal flows are partially controlled by a tidegate. It appears to function as a recreational pond for local landowners.

Figure 18. Grasser's Lagoon.



*Lake Habitat.* Not applicable.

*Biological Processes.* No information was located.

*Recommendations.*

- Acquire the parcel containing Grasser's Lagoon.

- Re-vegetate the riparian buffer surrounding the north and west side of Grasser's Lagoon.
- Conduct further analysis of the tidegate associated with Kennedy Lagoon.
- Investigate the tributary draining into Grasser's Lagoon for its potential for salmon habitat.

### Race (33)

*Access.* Not an issue.

*Freshwater and Tidal Flooding.* Presumed to not be an issue.

*Channel Conditions and Sediment.* Needs further investigation.

*Riparian Conditions.* Needs further investigation.

*Water Quality.* No data were located.

*Hydrology.* Needs further investigation.

*Estuarine and Nearshore Habitat.* Needs further investigation.

*Lake Habitat.* Not applicable.

*Biological Processes.* Needs further investigation.

### *Recommendations.*

- Only one member of the TAG was able to visit this site due to time constraints. Additional field analysis is warranted.
- Investigate options for acquisition and conservation easements.
- Revegetate the riparian buffer.
- Conduct a time-series analysis of the channel configuration and sedimentation in relation to past nearshore development.

### Swantown (13)

*Access.* The tidegate at the northwest corner of the Swantown marsh is limiting salt water exchange and precluding salmonid access to the Swantown stream system (Sheldon and Associates 1999) (Figure 19). Discharge from the marsh is controlled by two inoperable 30-cm culverts with rusted out tidegates that discharge into an old diked roadside ditch adjacent to West Beach Road (KCM 1998). This ditch discharges through



76-cm and 61-cm culverts and a pair of tidegates (replaced in 1991), and then into the Strait of Juan de Fuca.

The culverts connecting the marsh to saltwater are undersized and too long to allow for good fish passage. The drainage ditches connecting to the tidegates are not currently directly connected to the open water area of the wetland. When the tidegates were constructed the open water area of the lake was reduced in size. Anadromous fish (chum, coho and coastal cutthroat) could potentially use Swantown Creek up to the culvert at Fairway Lane at the Whidbey Golf and Country Club (Johnson and Kearsley 1999). The creek is pumped out of the golf course ponds at this location.

Figure 19. Tidegate at Swantown Marsh.



*Freshwater and Tidal Flooding.* The tidal exchange into the Swantown marsh has been modified through the construction of the berm along West Beach Road (Figure 20), and the installation of the tidegates. Several residential homes have been constructed along the shoreline between the Strait of Juan de Fuca and the marsh. The freshwater floodplain has also been highly modified through diking and ditching. During storm events, the water level in the marsh may rise above West Beach Road (which functions as a dike) and flood septic fields (KCM 1998). Future development in the upper watershed is expected to exacerbate flooding in this area (KCM 1998).

*Channel Conditions and Sediment.* Swantown Creek has been diked and ditched throughout much of its extent. No data were located concerning sediment.

*Riparian Conditions.* The riparian corridor associated with Swantown Creek is in relatively poor condition. Much of the vegetation upstream of the wetland has been cleared (Kearsley 2000). A short section of the stream between the golf course and the farm has a narrow mixed vegetation forested/shrub buffer. The riparian area in the golf course is a manicured lawn with some ornamental trees. The upper watershed has an extensive wetland system that has been heavily impacted by small farms and residential development. There is virtually no buffer along West Beach Road.

Figure 20. Swantown Marsh and West Beach Road.



The wetland is only partially functioning as salt marsh habitat. About 40 % of the wetland currently exists as salt marsh habitat, the remainder being freshwater marsh (40 %), mudflat (20 %), and open water (10 %) (Sheldon and Associates 1999). Exotic species are present.

*Water Quality.* Swantown is one of five sites monitored for water quality and sediment quality as part of the North Whidbey Island Baseline Water Quality Monitoring Program (Herrerra Environmental Consultants, Inc. 1995). The monitoring station is located on an intermittent stream at a culvert crossing of Fairway Lane just downstream of the Whidbey Country Club golf course. The stream is channelized and receives surface runoff from the sub-basin.

The monitoring results for temperature and dissolved oxygen are presented in Table 18.

Stream temperatures were cool (9.4 °C or less). Dissolved oxygen levels (8.1 mg/l or more) violated the state standard on one occasion (March 20, 1995). Water temperature would be expected to be higher and dissolved oxygen concentrations lower during the summer months. Summer is often the time period when these parameters can be most problematic for fish. Elevated turbidity, total phosphorus, nitrate, and fecal coliform bacteria were also detected.

The sediment quality in Swantown was the worst of the five County monitoring stations. High concentrations of copper, zinc and total petroleum hydrocarbons were detected.

*Hydrology.* The Swantown marsh receives surface runoff and flow from a ditched channel (Sheldon and Associates 1999). The wetland is connected to ponds on the Whidbey Golf and Country Club. Water enters the wetland at the southeast corner and flows along the south edge of the site until entering a ditch paralleling West Beach Road. There are two parallel saltwater ditches along the west side of the wetland. The westernmost ditch does not appear to be connected to the wetland, but receives seepage through the berm (Sheldon and Associates 1999). The headwaters of the stream are formed by wetlands.

Table 18. Select water quality and streamflow monitoring results, Swantown Creek (ICPW 1997).

	Storm 1	Storm 2	Storm 3
<b>Sample Collection</b>			
Number of samples	3	3	3
Begin date	10/31/94	11/8/94	3/20/95
Begin time	0355	2145	0220
End date	10/31/94	11/9/94	3/20/95
End time	0855	0430	0610
<b>Hydrology</b>			
Mean flow (m <sup>3</sup> /s)	0.0003	0.00003	0.001
Peak flow (m <sup>3</sup> /s)	0.0006	0.0001	0.001
Total rainfall (cm)	0.68	0.48	0.71
Antecedent dry period (days)	2.5	2.0	6.0
<b>Analytes</b>			
Temperature (C)	9.4	7.7	8.0
Dissolved oxygen (mg/l)	10.3	9.8	8.1

*Lake Habitat.* Not applicable.

*Biological Processes.* Exotic vegetation is present but may be eradicated or reduced by increasing tidal inflows.

*Recommendations.*

- Explore remaining acquisition or conservation easement opportunities for properties in the vicinity of Swantown marsh and the riparian corridor along Swantown Creek.
- Remove or repair the culverts, tide gate and other drainage structures connecting Swantown Marsh to saltwater to allow for fish passage. Restore the open connection to saltwater by creating an open channel between West Lake Road. Install a large box culvert or conspan or bridge under the road south of the Swantown community.
- Fill in the drainage ditches paralleling West Lake Road and other ditches in the area. Allow natural drainage channels to form within the wetland. Reconstruct the stream channel in the lowland farmlands.
- Remove exotic species and revegetate the riparian areas associated with the salt marsh and stream channel.
- Evaluate the potential effect of the existing sea walls on the beach with regards to maintaining the proposed channel mouth.

- Monitor water quality draining to the marsh.
- Evaluate the potential for flooding from upstream development.
- Evaluate the stability of West Beach Road (which is constructed on peat) under modified tidal conditions.
- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of Swantown Creek.
- Develop a plan to restore and manage the Swantown Creek system for the reestablishment of coastal cutthroat and anadromous salmon.

#### Useless (Deer Lagoon and Lone Creek) (99)

*Access.* A tidegate blocks fish access and saltwater from the lagoon area in the middle of Deer Lagoon to the wetland located to the west. The tidegate is located at the northwest corner of the lagoon, just north of the junction of the two dikes forming the west boundary of the lagoon. The inner dike is shorter and older. The outer dike is armored. The shores of the lagoon are also armored. The dike extending around the north and west perimeter of the westernmost wetland blocks access to more land that probably once functioned as a salt marsh. The dike that runs north along the east side of the lagoon blocks the connection to Lone Creek and more potential salt marsh habitat. The standpipe culvert at the outlet of Lone Lake can prevent fish from entering and using the waterbody as rearing habitat.

*Freshwater and Tidal Flooding.* A southerly fetch of about 18 km contributes to the potential for tidal flooding during large storm events. On a day-to-day level, the diking and armoring system prevents tidal waters from flooding the area that once functioned as an estuary. Today the 384 ha site is estimated to be about 60 % freshwater wetland, 20 % mudflat, 15 % open water and 5 % salt marsh (Sheldon and Associates 1999).

Low depression areas at the western and eastern ends of Sunlight Beach Road are prone to flooding (FEMA 1995). A pump is located on the east dike at the northeast corner of the lagoon. It has been used to pump fresh water from a dredged channel of Lone Creek into the Deer Lagoon.

*Channel Conditions and Sediment.* There are no specific data concerning channel conditions and sediment for Lone Creek or the within the historic estuary. Most of the channels have been modified by diking and ditching. Lone Creek has been ditched and channelized throughout much of its extent (Johnson and Kearsley 1999).

*Riparian Condition.* The stream's riparian area is comprised of a mosaic reflecting the mixed land uses in the watershed. Most of the stream has been impacted by residential

development and agricultural practices, leaving few natural vegetative buffers. There are a few short sections with relatively undisturbed areas that are dominated by immature forest/shrub stands. Invasive plants, including reed canarygrass and blackberries, are present in most of the creek system.

The riparian area associated with Lone Lake is a mixture of residential and agricultural land and wild thick patches of shrubs. The upper watershed above the lake appears to be a mature forest although impacts from residential development are beginning to impact this area.

The natural wetland and riparian vegetation of Deer Lagoon has been extensively modified through direct removal and hydrological changes. The area between the west dike and Double Bluff Road is now a freshwater wetland. The land east of the east dike is also a freshwater wetland, dominated by cattail, hard-stem bulrush, reed canarygrass and pasture grasses. The modifications that have taken place have facilitated the invasion of exotic species. Approximately 10 % to 15 % of the site is dominated by invasive exotic species, mainly reed canarygrass.

*Water Quality.* No water quality data were located for this report. Nutrient concentrations may be elevated as a result of fertilizer application on turf areas. Septic systems may also be contributing nutrients and fecal coliform bacteria under certain groundwater conditions. Salinity values are unknown.

*Hydrology.* As discussed above, the hydrology of Lone Creek and the historic estuary has been highly modified by agricultural and residential land use practices. No specific data were located.

*Estuarine and Nearshore.* Deer Lagoon once functioned as one of the largest estuaries in WRIA 6, occupying much more area than it does today. It has been highly modified by agricultural activities but has high restoration potential. The nearshore area has been extensively developed for residential use.

*Lake Habitat.* Lone Lake is one of four lakes monitored by the WDOE as part of the Lake Water Quality Assessment Program. The WDOE has classified the lake as eutrophic based on water quality data collected as part of this program. The WDFW owns a public access site on the north shore of the lake which is open year round (WDFW 1999). The agency stocks the lake with rainbow trout.

*Biological Processes.* Further investigation is warranted. Stocking impacts are unknown.

#### *Recommendations.*

- Acquire the land west of lagoon for conversion back to a saline ecosystem.
- Remove or break the double-dike system at the west end of lagoon. Allow tidal channels to form through natural tidal processes. A new dike may need to be

constructed between the western wetland and the beach homes to protect residents from flooding during storm surge/high tide conditions.

- Design and implement a vegetation monitoring program.
- Monitor the saltwater areas for *Spartina* and implement control measures if necessary.
- Acquire the pasture area east of the lagoon to restore the connection between the lagoon and Lone Creek. A new dike may need to be constructed between the western wetland and the beach homes to protect residents from flooding during storm surge/high tide conditions.
- Remove or break the east dike at the east side of the lagoon.
- Reconfigure the reach of Lone Creek that flows through this area. Restore and revegetate the riparian buffer.
- Remove the standpipe culvert at the outlet of Lone Lake and re-establish the natural stream channel.
- Provide protection for the riparian buffer through acquisition or conservation easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of Lone Creek.
- Develop a plan to restore and manage the stream system for the reestablishment of coastal cutthroat and anadromous salmon

## **Camano Island**

### Boom (16)

*Access.* Access is not an issue for most of the English Boom salt marsh.

*Freshwater and Tidal Flooding.* The northern portion of the marsh has been cut off from tidal influence by dikes.

*Channel Conditions and Sediment.* Channel conditions may be altered as a result of *Spartina* infestation.

*Riparian Conditions.* *Spartina* has invaded the shoreline along the edge of the salt marsh.

*Water Quality.* No water quality data were located for this report. Water quality is probably not an issue.

*Hydrology.* English Boom receives freshwater inflows from surface runoff.

*Estuarine and Nearshore Habitat.* The *Spartina* infestation is probably the biggest threat to the health of the English Boom salt marsh. It is being managed under a control plan by the WDFW and Island County Noxious Weed Board. The nearshore habitat is undeveloped.

*Biological Processes.* *Spartina*, if uncontrolled can alter the biological and physical processes of the marsh.

*Recommendations.*

- Acquire (through acquisition or easement) additional salt marsh habitat at English Boom, including the area near Davis Slough that is currently impacted by dikes.
- Remove the dike and reestablish the salt marsh system.
- Continue to eradicate *Spartina* in concert with control efforts underway in the Stillaguamish delta and Port Susan, and monitor annually for new infestation.

### Carp (28)

*Access.* Access is the major factor limiting salmonid use of Carp Creek. Two access problems have been identified. The first is located at Madrona Beach Road. The 18-in culvert extends to Sunset Drive and is perched about 0.6 m above the stream surface. The second is located at Sunset Drive. A 50.8-cm concrete culvert extends from Sunset Drive to Saratoga Passage. Removal of the fish passage barriers would allow chum salmon to spawn in the lower reaches of the stream. There is potential for salmonid use from the mouth to Carp Lake.

*Freshwater and Tidal Flooding.* Flooding occurs on Sunset Drive and Madrona Beach Road because of the undersized culvert (KCM 1998).

*Sediment and Channel Conditions.* No data were located.

*Riparian Conditions.* The middle section of Carp Creek is highly impacted by residential development. The existing riparian buffers are narrow and highly manicured.

*Water Quality.* No data were located.

*Hydrology.* The headwaters of Carp Creek are formed by hillside springs in forested land.

*Estuarine and Nearshore Habitat.* The estuary has been filled and the mouth of the stream tightlined.

*Lake Habitat.* Additional information is needed.

*Biological Processes.* No information was located.

*Recommendations.*

- Replace the perched culvert at Madrona Beach Road with a new culvert that will allow for fish passage.
- Acquire (through acquisition or easement) the lot at Sunset Drive, remove the concrete culvert at the mouth of the stream, and restore an open channel.
- Remove and reconfigure the fish passage barrier at the tributary.
- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of the stream.
- Develop a plan to restore and manage the stream system for the reestablishment of coastal cutthroat and anadromous salmon.

Cavalero (32)

*Access.* A 61-cm perched culvert downstream of East Camano Drive is the main access problem associated with Cavalero Creek. If this structure were replaced with a fishway or an oversized baffled culvert, salmonids could use the creek system to East Camano Drive (Johnson and Kearsley 1999). Downstream, a 61-cm culvert is located at Country Club Drive. Here the stream channel requires some vegetation management, but the culvert allows for fish passage. The mouth of Cavalero Creek is marked by two tidegates. The tidegates allow for fish passage.

*Freshwater and Tidal Flooding.* No data were located.

*Sediment and Channel Conditions.* There is no evidence that sedimentation is a concern in this sub-basin (Kearsley 2000). The channel conditions appear to be stable throughout most of the areas that have been investigated.

*Riparian Conditions.* The riparian habitat of Cavalero Creek is generally intact. Invasive exotic species are present in some locations where land disturbance has occurred. Upstream of County Club Drive, watercress, blackberries and willows are clogging the stream channel. Lawn clippings were also found on the stream bank.

*Water Quality.* No data were located.

*Hydrology.* The headwaters are formed by hillside springs and wetlands (Kearsley 2000).

*Estuarine and Nearshore Habitat.* The mouth of the stream has been tightlined under a residential structure. The associated estuary was probably destroyed by fill and



bulkheads (Kearsley 2000). There is a dredged lagoon that receives a large volume of runoff from adjacent developments and hillside springs (Johnson and Kearsley 1999). A log bulkhead has been constructed on the nearshore side of a sandfill parking lot. Invasive exotic plant species are present.

*Lake Habitat.* Not applicable.

*Biological Processes.* No data were located.

*Recommendations.*

- Replace the 61-cm culvert with a fishway or an oversized baffled culvert to allow salmonids access to East Camano Drive.
- Implement vegetation management at the area near the culvert at Country Club Drive.
- Further analysis is warranted.

#### Elger (43)

*Access.* The historical topographic map seems to indicate that the sand spit now separating the Elger marsh from Saratoga Passage was constructed to allow residential development. The inlet channel to the marsh appears to be filling with sediment. The marsh is choked with thousands of logs (Figure 21). It is unknown how this may be impacting fish use of the marsh.

*Freshwater and Tidal Flooding.* Additional analysis is warranted to determine the origin of the sand spit and how it may be impacting tidal processes within the marsh.

*Channel Conditions and Sediment.* Additional analysis is warranted to determine the origin of the sand spit and how it may be impacting the channel inlet to the marsh.

*Riparian Conditions.* Additional information is needed.

*Water Quality.* No data were located.

*Hydrology.* Elger marsh receives freshwater from surface runoff from the surrounding hillslopes.

*Lake Habitat.* Not applicable.

*Biological Processes.* Additional analysis is warranted concerning the origin of the logs within the marsh and how they might be affecting biological processes.

Figure 21. Elger Marsh.



*Recommendations.*

- Elger Marsh received only a cursory review from the TAG. Additional information is needed concerning the history of the marsh and the logs within it, the origin of the sand spit, and whether the spit has contributed to a reduction in the channel inlet. View lots are still for sale on the spit.

Livingston (Iverson Parcel) (20)

*Access.* Fish passage to the Iverson parcel is totally blocked by the dike that runs on the northwest side of the property and a tidegate.

*Freshwater and Tidal Flooding.* Dikes prevent tidal waters from entering the Iverson property.

*Channel Conditions and Sediment.* The natural distributary channels within the historic salt marsh have been highly modified for farming purposes.

*Riparian Conditions.* All of the wetland and riparian vegetation within the Iverson property has been removed to allow for farming. *Spartina* has invaded the emergent wetland outside of the dike.

*Water Quality.* No data were located for this report.

*Hydrology.* The Iverson property receives freshwater from the surrounding hillslopes. Hydrology is not an issue pertaining to restoration.

*Estuarine and Nearshore Habitat.* The dikes and tidegate prevent saltwater from entering the historic salt marsh. *Spartina* has invaded the emergent wetland outside of the dike.

*Lake Habitat.* Not applicable.

*Biological Processes.* An infestation of *Spartina* could alter the biological and physical processes of the nearshore area.

*Recommendations.*

- Restore the Iverson property to a natural salt marsh by removing the dike and tidegate on the northwest side of the site. Sidecast the dike material into the large ditch paralleling the north side of the dike.
- Restore natural channels within the farmland and fill existing ditches where needed.
- Allow the farmland to naturally restore itself to salt marsh habitat. Some re-vegetation may be needed.
- Eradicate *Spartina* outside of the diked area and monitor the entire site annually to prevent reinfestation.
- Explore additional acquisition options.

#### Onamac (Chapman Creek) (35)

*Access.* Fish passage is obstructed by a 61-cm culvert under West Camano Drive. The water discharges about 3 m above the ground, and is undermined at the outfall (KCM 1998). This culvert was damaged by flooding in 1996 and is scheduled for replacement within 5 years (Johnson and Kearsley 1999). A small dam was constructed near Chapman Road to create a small pond. A series of log wiers create pools that enable the fish to migrate through the system (Figure 22). The dam does not appear to be blocking fish passage.

*Freshwater and Tidal Flooding Processes.* The topography of the Chapman Sub-basin has precluded the establishment of a saltmarsh at the mouth of Chapman Creek. Flooding has been documented to occur at Chapman Road as a result of the deteriorating culvert (KCM 1998).

Figure 22. Fish wiers on Chapman Creek.



*Sediment and Channel Conditions.* While the constructed pond near Chapman Road does not pose access problems, these types of structures can contribute to elevated stream temperatures and may trap sediments. Chapman Creek has also been routed into a ditch at this location. The headwaters of Chapman Creek have been converted into a mini golf course with a series of ponds and turf to the edge of the channel.

*Riparian Conditions.* The riparian zone of Chapman Creek is in relatively good shape in the vicinity of West Camano Drive. Here there is mostly native forest vegetation and there is good canopy cover (Johnson and Kearsley 1999). The buffer on the right bank has been limited by a road that is parallel to the creek. Exotic plants are invading the riparian area near the pond and culvert at Chapman Road. Reed canarygrass has dominated a wetland between Chapman Road and the headwaters.

*Water Quality.* No data were located.

*Hydrology.* No data were located.

*Estuarine and Nearshore.* Bulkheads associated with residential development (Figure 23) have heavily altered the nearshore habitat.

*Lake Habitat.* Not applicable.

*Biological Processes.* Exotic vegetation is present in some locations.

*Recommendations.*

- Explore acquisition options at the mouth of the stream.

Figure 23. Nearshore and mouth of Chapman Creek.



- Replace the culvert and outfall at West Camano Drive to allow for fish passage, and build a set of structures to address gradient concerns.
- Remove invasive exotic vegetation at the identified locations along the stream corridor.
- Re-route the creek out of the ditch and into the adjacent wetland near the pond.
- Add root balls to the pools associated with the pond to provide instream cover.
- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters.
- Develop an action plan to restore and manage the stream system for the reestablishment of coastal cutthroat and anadromous salmon.

#### Triangle (Kristofferson Creek) (26)

*Access.* Access to Kristofferson Creek from Triangle Cove is a factor limiting salmonid use. A 1.2-m culvert at Russell Road appears to be undersized, backing up water upstream of the road. The three small (51 cm to 61 cm) culverts at Barnum Road also pose access problems, and should be replaced with a single arch or conspan. When the culverts are replaced in these two locations, fish should have access to the mainstem of the stream to Kristofferson Lake. The wood at the head of the bay may impede fish passage under low tide conditions. The golf course and residential community have heavily altered the east branch of the stream, eliminating access to the upper reaches (Kearsley 2000).

*Floodplains and Tidal Exchange.* Triangle Cove has an open channel connecting to Port Susan. The cove has a natural pattern of distributary channels. The entire bay is inundated at high tide.

*Sediment and Channel Conditions.* There are no data on sediment or channel conditions. The stream does appear to be ponding between Barnum and Russell Roads and upstream of Russell Road as a result of undersize culverts. A small private dam structure between Russell and Barnum Roads is also ponding water. The east fork of Kristofferson Creek has been severely altered by the golf course.

*Riparian Condition.* The riparian zone is characteristic of the mixed land use in the watershed (Kearsley 2000). Recreational, residential, commercial, and agricultural land uses have all created impacts. There are some reaches that remain naturally vegetated because the land has not been developed. There is an extensive forested-scrub/shrub wetland just north of Camano Drive. A portion of its lower reach appears to have an extensive immature mixed stand forested buffer. Approximately 70 % of the wetland is salt marsh habitat, the remainder being mudflat (20 %), open water (10 %), and freshwater marsh (less than 1 %) (Sheldon and Associates 1999). Approximately 94 ha of the marsh are invaded by *Spartina* (Heimer 1999).

*Water Quality.* No water quality data were located for this report. The golf course may be contributing nutrients and other contaminants to the stream and the estuary. Septic systems associated with the houses on the sand spit may also be contaminating water quality during high tides.

*Hydrology.* No streamflow data were located for this report.

*Estuarine and Nearshore.* A northeast-trending sand spit separates Triangle Cove from Port Susan (Figure 24). The spit is lined with residential homes on each side of the access road.

*Lake Habitat.* Additional investigation is warranted.

*Biological Processes.* *Spartina* poses the biggest threat to the Triangle Cove estuary.

*Recommendations.*

- Explore acquisition options for Triangle Cove.
- Explore acquisition options for the property riparian to the stream between Triangle Cove and Russell Road. Remove the dam from the stream on the private property and restore the stream channel.



Figure 24. Sand spit at Triangle Cove.



- Continue *Spartina* control work within Triangle Cove and annual monitoring to prevent reinfestation.
- Close or remove the County dirt road to restore an open stream channel into the estuary. If it is not feasible to do this replace the 3 culverts with a large arched culvert.
- Replace the culverts at Russell Road with a larger bottomless arched culvert.
- Provide protection for the riparian buffer through acquisition or easements, and initiate partnerships with local landowners to conduct riparian restoration projects.
- Identify and protect the headwaters of the stream.
- Develop a plan to restore and manage the stream system for the reestablishment of coastal cutthroat and anadromous salmon.

## **ASSESSMENT OF HABITAT LIMITING FACTORS**

The habitat limiting factors discussed in this report differentially affect salmonids as a result of the differences in the timing and manifestation of their life history stages. Table 19 summarizes the habitat limiting factors discussed in the previous section.



**Table 19: Summary of habitat factors in WRIA 6**

	Habitat Factor								
Sub-basin Name	Access	Flooding/Tides	Channels/Sediment	Riparian	Water Quality	Hydrology	Estuary/Nearshore	Lakes	Biological/Exotics
Whidbey									
Berry (Greenbank)	X	X	ND	X	ND	ND	X	NA	X
Brighton (Old Clinton)	X	ND	X	LD	ND	ND	ND	NA	ND
Crescent	X	X	X	X	X	LD	X	NA	X
Crockett	X	X	ND	X	X	X	X	NA	X
Cultus	X	X	X	X	X	LD	X	NA	X
Deer	X	NA	X			X	X	ND	ND
Dugualla	X	X	ND	X	X	ND	X	ND	ND
Glendale	X	X	X	X	ND	ND	X	NA	X
Hancock					ND	ND		NA	X
Harrington	LD	LD	LD	X	ND	ND	X	NA	X
Holmes	X	X	ND	ND		X	ND	NA	ND
Houston	X								
Langley	X	ND	X	X	X	ND	ND	NA	ND
Maxwelton	X	X	X	X	X	X	X	ND	X
Penn (Grasser's Lagoon)				X	ND	ND		NA	ND
Penn (Kennedy Lagoon)	X	X		X	ND	ND	X	NA	ND
Race			ND	ND	ND	ND	ND	NA	ND
Swantown	X	X	X	X	X	X	X	NA	X
Useless	X	X	X	X	X	X	X	X	X
Camano									
Boom		X	X	X	ND	ND	X	NA	X
Carp	X	X	ND	ND	ND	ND	ND	ND	ND
Cavalero	X	ND	ND	ND	ND	ND	X	NA	ND
Chapman	X	X	X	X	ND	ND	X	NA	X
Elger	LD	LD	LD	ND	ND	ND	X	NA	ND
Livingston (Iverson)	X	X	X	X	ND	X	X	NA	X
Triangle	X	X	X	X	ND	X	X	ND	X

DG - Data gap

LD -Limited data

NA - Not applicable

## **BEST FUNCTIONING HABITAT IN NEED OF PROTECTION**

Properly functioning habitat is the most cost-effective habitat to protect. The ability to restore degraded habitat back to its proper function is limited by our technical knowledge of the complex physical, chemical and biological processes operating within and between ecosystems.

Within WRIA 6, the vast majority of habitat has been impacted, at some level, by human activities. Habitats in need of protection within the sub-basins and along the coastal shoreline are those areas that still retain a significant portion of their original habitat functions or possess a high potential for re-establishing properly functioning habitat.

Lake Hancock and Perego's Lagoon are the best examples in WRIA 6 of coastal intertidal environments that still resemble the native ecosystems. In 1984, both sites were recommended for protection along with 18 other coastal wetlands in Puget Sound (Kunze 1984). As a result, both sites are now managed as protected areas. Lake Hancock is under ownership of Whidbey NAS and The Nature Conservancy of Washington. Perego's Lagoon is protected by the National Park Service as part of Ebey's Landing.

In this document, a few other small, coastal wetlands and freshwater streams were identified to be functioning relatively well under natural processes but still existing in private ownership without legal habitat protection. These shoreline sites are all on the east coast of Whidbey Island and include Grasser's Lagoon, Harrington Lagoon, and Race Lagoon. Cultus Bay, Triangle Cove, Deer Lagoon, and Crockett Lake are also deserving of protection but will require restoration.

Freshwater stream systems that still maintain a low level of development and relatively healthy riparian corridors include Glendale, Cultus, North Bluff, Chapman, and Deer Creeks. All of these streams have barriers to fish access that need to be remedied, and will require some localized riparian and channel restoration, but the existing hydrological condition is still relatively unimpaired and the streamflows are presumed to be perennial and capable of supporting salmonids throughout much of their length.

A considerable (and yet unquantified) amount of the nearshore habitat in WRIA 6 has been seriously impacted by residential, agricultural, and other forms of development. Those areas remaining intact need to be inventoried and mapped. The WDNr and Island County Beachwatchers are in the process of doing this. Once these areas are identified, they need protection from future development. The nearshore habitat in this watershed is vital to the juvenile life stages for many salmonid species originating from river basins in north Puget Sound and potentially other areas as well.

## DATA GAPS

The data gaps shown in Table 20 emerged through the course of preparing this report and are intended to guide future inventory and research needs. The WRIA 6 TAG reviewed and ranked them according to their relative importance into three categories: high, moderate, and low. Some data gaps are supported by other groups (Marine Resources Committee and Beachwatchers) that have similar data and information needs.

**Table 20. Data gaps in WRIA 6.**

Relative Priority	Data/Information Gap	Source
High	Systematic inventory of freshwater salmonid distribution and genetics	TAG
	Systematic inventory of marine salmonid distribution and genetics	TAG
	Nearshore, estuarine, salt marsh and lagoon habitat inventory and GIS map	TAG/MRC
	Use and importance of nearshore, estuarine, salt marsh and lagoon habitat by salmonids	TAG
	Riparian habitat inventory and GIS map production	TAG
	Completion of the physical habitat survey and GIS map production	TAG
	Completion of the culvert inventory and GIS map production	TAG
	Completion of the shoreline armoring inventory and GIS map production	TAG/MRC/Beachwatchers
	Identify high quality habitat for protection opportunities	TAG
	Install gages and monitor streamflows in known and potential fish-bearing streams	TAG
	Historic and current beaver activity in Maxwellton watershed in relation to salmon	WRAC
Moderate	History, extent and impact of invasive exotic species in riparian/aquatic habitats	TAG
	History of nearshore development	TAG
	Fecal coliform/nutrient sources in relation to DO in freshwater and marine habitats	TAG
	Importance of high intertidal beach environment to nutrient cycling	TAG
	Compile historical information on salmonid distributions and populations	TAG
	Analysis of processes occurring in estuarine, salt marsh and lagoons	TAG
	Survey boat ramps to identify obstructions to natural beach processes	TAG
Low	Known and potential use of lakes by salmonids	TAG
	Field survey of unclassified creek systems per WDNR code	TAG

## GLOSSARY

*Anadromous fish:* Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

*Aquifer:* Water-bearing rock formation or other subsurface layer.

*Basin:* The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

*Basin flow:* Portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion, or other human activities.

*Buffer:* An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

*Channelization:* Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

*Channelized stream:* A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

*Channel stability:* Tendency of a stream channel to remain within its existing location and alignment.

*Discharge.* The volume of water flowing in a stream at a given place and within a given period of time, usually expressed as cubic meters per second ( $\text{m}^3/\text{s}$ ) or cubic feet per second (cfs).

*Distributaries:* Divergent channels of a stream occurring in a delta or estuary.

*Diversity:* Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness*.

*Ecological restoration:* Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

*Ecosystem:* Biological community together with the chemical and physical environment with which it interacts.

*Ecosystem management:* Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

*Endangered Species Act:* A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife and plants be protected and restored.

*Endangered species:* Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

*Escapement:* Those fish that have survived all fisheries and will make up a spawning population.

*Estuarine:* A partly enclosed coastal body of water that has free connection to open sea, and where seawater and freshwater meet and mix.

*Eutrophic:* Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic*.

*Evolutionary Significant Unit (ESU):* A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

*Fish passage barrier:* Any structure that impedes the upstream or downstream movement of fish.

*Flood:* An abrupt increase in water discharge.

*Floodplain:* Lowland areas that are periodically inundated by the lateral overflow of streams or rivers.

*Flow regime:* Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

*Habitat:* The place where a plant or animal lives during all or part of its life cycle.

*Healthy stock:* A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

*Hydrograph:* Chart of water levels over time.

*Hydrology:* Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

*Impervious surface:* Surfaces that restrict or reduce the infiltration of surface water into soils (such as pavement, roof tops, compacted soils, etc.).

*Intermittent stream:* Stream that has interrupted flow or does not flow continuously. Compare *perennial stream*.

*Large woody debris (LWD):* Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. LWD is also referenced

to as “coarse woody debris” (CWD). Either term usually refers to pieces at least 20 inches (51 cm) in diameter.

*Life history:* A history of the changes through which an organism passes in its development from the primary stage to its natural death.

*Limiting factor:* Single factor that limits a system or population from reaching its highest potential.

*Macroinvertebrates:* Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

*Mainstem:* The principal stream or channel for any drainage basin.

*Mixed stock:* A stock whose individuals originated from commingled native and non-native parents, or a previously native stock that has undergone substantial genetic alteration.

*Native:* Occurring naturally in a habitat or region; not introduced by humans.

*Native stock:* An indigenous stock of fish that has not been substantially affected by genetic interactions with non-native stock or by other factors, and is still present in all or part of its original range.

*Net pen:* A fish rearing enclosure used in lakes and marine areas.

*Non-Point source pollution:* Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

*Parr:* Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt*.

*Reach:* Any specific section of a stream’s length.

*Rearing habitat:* Areas required for the successful survival to adulthood by young animals.

*Recovery:* The return of an ecosystem to a defined condition after a disturbance.

*Redds:* Nests made in gravel (particularly by salmonids); consisting of a depression that is created and the covered.

*Resident fish:* Fish species that complete their entire life cycle in freshwater. Coastal cutthroat may assume this life history type.

*Riffle:* Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

*Riparian:* Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

*SASSI*: Salmon and Steelhead Stock Inventory.

*SSHIAP*: A salmon, steelhead, habitat inventory and assessment program directed by the Northwest Indian Fisheries Commission.

*Salmonid*: Fish of the family salmonidae, including salmon, trout chars, and bull trout.

*Salmon*: Includes all species of the family Salmonid.

*Scour*: The removal of material by erosion due to moving water.

*Sediment*: Material carried in suspension by water, which will eventually settle to the bottom.

*Sedimentation*: The process of sediment being carried and deposited in water.

*Side channel*: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

*Siltation*: The deposition of suspended materials, usually as a result of reduced water velocity.

*Slope stability*: The degree to which a slope resists the downward pull of gravity.

*Smolt*: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt state follows the parr state. See *parr*.

*Stock*: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.

*Stream order*: A classification system for streams based on the number of tributaries it has. The smallest unbranched tributary in a watershed is designated order 1. A stream formed by the confluence of 2 order 1 streams is designated as order 2. A stream formed by the confluence of 2 order 2 streams is designated order 3, and so on.

*Stream reach*: Section of a stream between two points.

*Stream types (as defined by WDNR)*:

Type 1: All waters within their ordinary high-water mark as inventoried in “Shorelines of the State”.

Type 2: All waters not classified as Type 1, with 20 feet or more between each bank’s ordinary high water mark. Type 2 waters have high use and are important from a water quality standpoint for domestic water supplies, public recreation, or fish and wildlife uses.

Type 3: Waters that have 5 or more feet between each bank's ordinary high water mark, and which have a moderate to slight use and are more moderately important from a water quality standpoint for domestic use, public recreation and fish and wildlife habitat.

Type 4: Waters that have 2 or more feet between each bank's ordinary high water mark. Their significance lies in their influence on water quality of larger water types downstream. Type 4 streams may be perennial or intermittent.

Type 5: All other waters, in natural water courses, including streams with or without a well-defined channel, areas of perennial or intermittent seepage, and natural sinks. Drainage ways having a short period of spring runoff are also considered to be Type 5.

*Sub-basin*: One of the smaller watersheds that combine to form a larger watershed.

*Tributary*: A stream feeding a larger stream or lake.

*Watershed*: Entire area that contributes both surface and underground water to a particular lake or river.

*Watershed rehabilitation*: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoration*.

*Watershed restoration*: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

*Weir*: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

*Wild stock*: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.



## REFERENCES CITED

- Anderson, D. 1999. Personal communication. Langley, WA.
- Aquatic Resource Consultants. 1997. Investigation of existing conditions in lower Glendale Creek. Department of Public Works, Island County, Coupeville, WA.
- Barnes, R. 1999. Unpublished streamflow data for Maxwellton Creek. Langley, WA.
- Barnes, R. 2000. Personal communication, Langley, WA.
- Base, D. 1997. Unpublished memorandum to Dave Anderson regarding the Maxwellton Creek tidegate and fish passage.
- Base, D. 1999. Personal communication. Washington Department of Fish and Wildlife, Colville, WA.
- Beauchamp, D., D. Pflug, and G. Lucchetti. 1987. Snohomish River juvenile salmon outmigration study 1987. Prepared by Northwest Enviro-Metric Services. Submitted by The Tulalip Tribes for the United States Department of the Navy. Contract No. N62474-86-C-0991. Everett, WA.
- Bernard, D., K. Hepler, J. Jones, M. Whalen, and D. McBride. 1995. Some tests of the "migration hypothesis" for anadromous Dolly Varden (southern form). Transactions of the American Fisheries Society 124: 297-307.
- Bochte, B. and A. Fitz. 1989. Summary and background information: proposed improvements to the Maxwellton tidegate. Maxwellton Salmon Adventure.
- Booth, D. and C. Jackson. 1997. Urbanization of aquatic systems: degradation thresholds, stormwater detention, and the limits of mitigation. Journal of the American Water Resources Association 33(5):1077-1090.
- Boule', M., N. Olmsted and T. Miller. 1983. Inventory of wetland resources and evaluation of wetland management in western Washington. Washington Department of Ecology, Olympia.
- Broadhurst, G. 1998. Puget Sound nearshore habitat regulatory perspective: a review of issues and obstacles. Puget Sound/Georgia Basin International Task Force, Puget Sound/Georgia Basin Environmental Report Series, Number 7. Olympia, WA.
- Burgner, R. 1991. Life history of sockeye salmon *Oncorhynchus nerka*, and methods for its study. Journal of Ichthyology 32(8):1-19.
- Burns, R. 1985. The shape and form of Puget Sound. University of Washington Press, Seattle, WA.

- Busby, D., T. Wainwright, G. Bryant, L. Leirheimer, R. Waples, F. Waknitz, and I. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U. S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-27. Seattle, WA.
- Cedarholm, C. and W. Scarlett. 1982. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater, Washington, 1977-1981. *In* E. Brannon and E. Salo (eds.), Proceedings of the salmon and trout migratory behavior symposium, p.98-110. University of Washington, Seattle.
- Chappell, C., J. Gamon, B. Stephens, and M. Sheehan. 1996. Significant biological features of Naval Air Station, Whidbey Island. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia WA.
- Collins, B. 1997. Effects of land use on the Stillaguamish river, Washington, ~1870 to ~1990: implications for salmonid habitat and water quality and their restoration. Report to the Tulalip Tribes Natural Resources Department (Marysville, WA), Snohomish County Department of Public Works (Everett, WA), Stillaguamish Tribe of Indians (Arlington, WA), and Washington Department of Ecology, Olympia.
- Dawley, E. et al. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Final report to Bonneville Power Administration, Contract DEA179-84BP39652, Portland, Oregon.
- Department of Commerce. 1870. Topographic map of Admiralty Bay T-1164. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Department of Commerce. 1871. Topographic map of Finger to Point Partridge T-1253. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Department of Commerce. 1872. Topographic map of Useless Bay. T-13886. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Department of Commerce. 1886. Topographic map of Port Susan and Stillaguamish River. T-1755. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Department of Commerce. 1887. Topographic map of Saratoga Passage and Holmes Harbor. T-1994. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Department of Commerce. 1889. Topographic map of Skagit Bay, Delta and River. T-2156. National Oceanic and Atmospheric Administration, Seattle, Washington.
- Doody, M. April 25, 1990. Court-ordered schedule of lake level may be an "improvement on nature." Whidbey News-Times.
- EA Engineering, Science and Technology. 1996. Integrated Natural Resources Management Plan: Naval Air Station Whidbey Island. Environmental Affairs, Naval Air Station Whidbey Island, Oak Harbor, WA.

- Easterbrook, D. 1968. Pleistocene stratigraphy of Island County, Washington. Water Supply Bulletin No. 25, Part I. Washington Department of Water Resources, Olympia.
- Edie, B. 1975. A census of juvenile salmonids of the Clearwater River basin, Jefferson County, Washington, in relation to logging. M. S. Thesis, University of Washington, Seattle.
- Entranco Engineers, Inc. and Independent Ecological Services. 1986. Crockett Lake drainage basin management study. Incorporated as "Exhibit A" of the Environmental Checklist/Assessment Regarding Options for Management of Water Levels in The Crockett Lake Drainage Basin, Whidbey Island, Island County, WA. Coupeville, WA.
- Everest, F. and D. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29: 91-100.
- Fakkema and Kingma. 1983. Bathymetric survey of Crockett Lake. Map prepared for Island County Drainage District No. 6.
- Federal Emergency Management Agency. 1995. Flood insurance study, Island County, Washington and incorporated areas. Bothell, WA.
- Fox, L. 2000. Personal communication. Chums of Maxwellton Salmon Adventure, Langley, WA.
- Franklin, J. and C. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8.
- Fresh, K. 1999. Personal communication. Washington Department of Fish and Wildlife, Olympia.
- Fuss, J. 1982. Age, growth and instream movement of Olympic Peninsula coastal cutthroat trout (*Salmo clarki clarki*). M. S. Thesis, University of Washington, Seattle.
- Gallion, M. 2000. Personal communication. Island County Marine Resources Committee. Coupeville, WA.
- Garrett, A. 1998. Interstream movements of coastal cutthroat trout (*Oncorhynchus clarki clarki*) in the Clearwater River, Jefferson County, Washington. M. E. S. Thesis, The Evergreen State College, Olympia, WA.
- Gersib, R. 1997. Restoring wetlands at a river basin scale, a guide for Washington Puget Sound operational draft. Washington State Department of Ecology, Publication No. 97-99, Olympia.
- Giger, R. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Commission, Corvallis Fisheries Resource Report No. 6.

- Glova, G. 1984. Management implications of the distribution and diet of sympatric populations of juvenile coho salmon and coastal cutthroat trout in small streams in British Columbia, Canada. *Prog. Fish Cult.* 46: 269-277.
- Groot, C. and L. Margolis. 1998. Pacific salmon life histories. University of British Columbia, Vancouver.
- Gustafson, R. et al. 1997. Status review of sockeye salmon from Washington and Oregon. National Oceanic and Atmospheric Administration Technical Memorandum. National Marine Fisheries Service-Northwest Fisheries Science Center-33.
- Hartman, G. and T. Brown. 1987. Use of small, temporary, floodplain tributaries by juvenile salmonids in a west coast rainforest drainage basin, Carnation Creek, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 44: 262-270.
- Hayman, R., E. Beamer, and R. McClure. 1996. FY 1995 Skagit River chinook restoration research. Skagit System Cooperative Chinook Restoration Research Progress Report No. 1. Final Project Performance Report in Compliance with NWIFC Contract 3311 for FY 95. La Conner, WA.
- Healey, M. 1980a. The ecology of juvenile salmon in Georgia Strait, British Columbia. p. 203-229 *In* W. McNeil and D. Himsworth (eds.), *Salmonid ecosystems of the North Pacific*. Oregon State University Press and Oregon State University Sea Grant College Program, Corvallis.
- Healey, M. 1980b. Utilization of the Nanaimo River estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. *Fisheries Bulletin* 77:653-668.
- Healey, M. 1982. Juvenile Pacific salmon in estuaries: the life support system. p. 215-341 *In* V. Kennedy (ed.), *Estuarine comparisons*. Academic Press, New York.
- Healey, M. 1991. The life history of chinook salmon (*Oncorhynchus tshawytscha*). p. 311-393 *In* C. Groot and L. Margolis (eds.), 1991. *Pacific salmon life histories*. University of British Columbia Press, Vancouver.
- Heard, W. 1998. Life history of pink salmon (*Oncorhynchus gorbuscha*). p. 121-232 *In* C. Groot and L. Margolis (eds.), 1991. *Pacific salmon life histories*. University of British Columbia Press, Vancouver.
- Hendrick, D. 1999. Personal communication. Washington Department of Fish and Wildlife, La Conner.
- Herrera Environmental Consultants, Inc. 1995. North Whidbey Island baseline water quality monitoring program. Island County Public Works. Coupeville, WA.
- Island County. 1974. Water pollution control and abatement plan. Coupeville, WA.

- Island County Department of Planning and Community Development. 1998. Island County comprehensive plan: policy plan and land use element. Coupeville, WA.
- Island County Public Works Department. 1997. North Whidbey Watershed nonpoint pollution prevention action plan. Coupeville, WA.
- Johnson, R. 1999. Personal communication. Washington Department of Fish and Wildlife, La Conner.
- Johnson, R. and J. Kearsley. 1999. Unpublished notes from field investigations, November 22-24, Whidbey and Camano Islands.
- Johnston, J. 1982. Life histories of anadromous cutthroat with emphasis on migratory behavior. In E. Brannon and E. Salo (eds.), Proceedings of the salmon and trout migratory behavior symposium, p.123-127. University of Washington, Seattle.
- Jones, J. and C. Siefert. 1997. Distribution of mature sea-run cutthroat trout overwintering in Auke Lake and Lake Eva in southeastern Alaska. In J. Hall, P. Bisson and R. Gresswell (eds.), Sea-run cutthroat: biology, management, and future conservation, p. 27-28. American Fisheries Society, Corvallis.
- Jones, M. 1985. Occurrence of ground water and potential for sea water intrusion, Island County, Washington. USGS Water Resources Investigations Report 85-4046. Tacoma, WA.
- June, J. 1981. Life history and habitat utilization of cutthroat trout (*Salmo clarki*) in a headwater stream on the Olympic Peninsula, Washington. M.S. Thesis, University of Washington, Seattle.
- Kearsley, J. 1998. Central/South Whidbey watershed assessment report. Island County Public Works, Coupeville, WA.
- Kearsley, J. 2000. Personal communication. Island County Public Works, Coupeville, WA.
- Kearsley, J. and J. Hossley. 1995. North Whidbey watershed assessment. Island County Public Works, Coupeville, WA.
- Kjelson, M., P. Raquel, and F. Fisher. 1982. Life history of fall-run juvenile chinook, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California. P. 393-411 In V. Kennedy (ed.), Estuarine comparisons. Academic Press, New York.
- Klope, M. 1999. Personal communication. NAS Whidbey, Oak Harbor, WA.
- Kramer, Chin and Mayo. 1998. Island County comprehensive stormwater and flood hazard management plan. Island County Public Works, Coupeville, WA.
- Kramer, D. 1987. Dissolved oxygen and fish behavior. Environ. Biol. Fish. 18:81-92.

- Kunze, L. 1984. Puget Trough coastal wetland sanctuaries: a summary report of recommended sites. Prepared for the Washington Department of Ecology, Olympia. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia.
- Levings, C. 1982. Short term use of a low tide refuge in a sandflat by juvenile chinook, *Oncorhynchus tshawytscha*, in the Fraser River estuary. Canadian Technical Report of the Fisheries and Aquatic Sciences 1111.
- Levings, C. and R. Thom. 1994. Habitat changes in Georgia Basin: Implications for resource management and restoration. In R. C. H. Wilson, R. J. Beamish, Fran Aitkens, and J. Bell (eds.), Review of the marine environment and biota of the Strait of Georgia, Puget Sound and Juan de Fuca Strait. Proceedings of the BC/Washington Symposium on the Marine Environment, January 13-14, 1994. Canadian Technical Report of Fisheries and Aquatic Sciences 1948. Marine Sciences Panel, British Columbia/Washington Environmental Cooperation Council.
- Levings, C., D. Boyle, and T. Whitehouse. 1995. Distribution and feeding of juvenile Pacific salmon in freshwater tidal creeks of the lower Fraser River, British Columbia. Fisheries Management and Ecology 2:299-308.
- Lowry, G. 1965. Movement of cutthroat trout (*Salmo clarki clarki* Richardson) in three Oregon coastal streams. Transactions of the American Fisheries Society 94(4):334-338.
- Lynn, B. November 1998. Nearshore habitat loss in Puget Sound: recommendations for improved management. Puget Sound/Georgia Basin International Task Force. Olympia, WA.
- MacDonald, J, I. Birtwell, and G. Kurzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell River estuary. Canadian Journal of Fisheries and Aquatic Sciences 44:1233-1246.
- McMahon, T. and L. Holtby. 1992. Behavior, habitat use, and movements of coho salmon (*Oncorhynchus kisutch*) smolts during seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 49:1478-1485.
- Michael, H. 1980. Sea-run cutthroat trout. In J. DeShazo (ed.), Sea-run cutthroat status report. Report 80-14, P. 187-190. Washington State Game Department, Fisheries Management Division, Olympia, WA.
- Miller, B. S., C. A. Simenstad, L. L. Moulton, K. L. Fresh, F. C. Funk, W. A. Karp, and S. F. Borton. 1977. Puget Sound baseline program nearshore fish survey. Washington Department of Ecology, Final Report: July 1974 – June 1977. Olympia.
- Nelson, K., A. Loch, and G. Lucchetti. 1997. Wild coho salmon indicator stock study for the Stillaguamish river. Tulalip Tribes Natural Resources Division, Final Report 97-2, Marysville.

- Nesbit, D. 1885. Tide marshes of the United States. Department of Agriculture miscellaneous special report no. 7. Washington, D. C.
- Newton, J., S. Albertson, K. Nakata, and C. Clishe. 1998. Washington State marine water quality in 1996 and 1997. Publication No. 98-338. Washington State Department of Ecology, Olympia.
- Nicholas, J. 1978. Life history differences between sympatric populations of rainbow and cutthroat trouts in relations to fisheries management strategy. *In* J. Moring (ed.), Proceedings of the Wild Trout-Catchable Trout Symposium, p.181-188. Oregon Department of Fish and Wildlife, Portland.
- Northwest Fisheries Science Center. 1999. Status review of coastal cutthroat from Washington, Oregon, and California. TM-37. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA.
- Parvin, K. 1998. Central/South Whidbey baseline water quality monitoring program water quality assessment. Island County Health Department, Coupeville, WA.
- Pauley, G., K. Oshima, K. Bowers, and G. Thomas. 1989. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) sea-run cutthroat. U. S. Fish and Wildlife Service Biological Report 82 (11.86). U. S. Army Corps of Engineers, TR EL-82-4.
- Pearcy, W. 1997. The sea-run and the sea. *In* J. Hall, P. Bisson and R. Gresswell (eds.), Sea-run cutthroat trout: biology, management, and future conservation, p.29-36. American Fisheries Society, Corvallis.
- Penttila, D. 1999. Documented spawning areas of the Pacific herring (*Clupea*), surf smelt (*Hypomesus*), and Pacific sand lance (*Ammodytes*) in Island County, Washington. WDFW, La Conner, WA.
- Pihl, L., S. Baden, R. Diaz, and L. Schaffner. 1992. Hypoxia-induced structural changes in the diet of bottom-feeding fish and Crustacea. *Mar. Biol.* 112:349-361.
- Pollock, M. 1998. Current and historic riparian conditions in the Stillaguamish river basin. Stillaguamish Tribe, Arlington, WA.
- Pollock, M. M., and G. R. Pess. 1998. The current and historical influence of beaver (*Castor canadensis*) on coho (*Oncorhynchus kisutch*) smolt production in the Stillaguamish river basin. Natural Resources Department, Stillaguamish Tribe, Arlington, WA.
- Puget Sound Water Quality Authority. 1990. Issue paper: protecting fish and wildlife habitat in Puget Sound. Puget Sound Water Quality Action Team, Olympia, WA.
- Ramsey, R. Personal communication. Clinton, WA.

- RW Beck and Associates 1986. Snohomish River juvenile salmon outmigration study 1987. Prepared by Northwest Enviro-Metric Services. Tulalip Tribes, Marysville, WA.
- Reid, Middleton and Associates. 1988. NAS Whidbey Island Master Plan. Department of the Navy, Western Division Naval Facilities Engineering Command.
- Roni, P., L. Weitkamp, and J. Scordino. 1999. Identification of essential fish habitat for salmon in the Pacific Northwest: initial efforts, information needs, and future direction. American Fisheries Society Symposium 22: 93-107.
- Ryan, K. 2000. Personal communication. Washington Maritime National Wildlife Refuge Complex, Port Angeles, WA.
- Schule, H. 1996. Wetland/stream assessment and evaluation of impacts pertaining to the proposed outdoor classroom. Prepared for Maxwelton Salmon Adventure Program by Greenbelt Consulting, Clinton, WA.
- Sheldon & Associates, Inc. 1999a. Data summary for Island County estuarine restoration program: six selected sites. Public Works Department, Island County, Coupeville, WA.
- Sheldon & Associates, Inc. 1999b. Island County Public Works Glendale Creek biological site assessment. Public Works Department, Island County, Coupeville, WA.
- Sheldon and Associates, Inc. 1999c. Island County wetland compensation program. Island County Public Works, Coupeville, WA.
- Shreffler, D. and R. Thom. 1993. Restoration of urban estuaries: new approaches for site location and design. Washington Department of Natural Resources, Olympia.
- Skagit Watershed Council. 1999. Action plan for protecting and restoring aquatic habitats in the Skagit and Samish river basins. Mt. Vernon, Washington.
- Sumioka, S. 1999. Personal communication, U.S. Geological Survey, Tacoma, WA.
- Thom, R. and L. Hallum. 1991. Long-term changes in the areal extent of tidal marshes, eelgrass meadows and kelp forests of Puget Sound. Puget Sound Estuary Program. Environmental Protection Agency, EPA 910/9-91-005. Region 10, Seattle, WA.
- Toba, D. 1999. Personal communication, Shellfish Biologist, Tulalip Tribes, Marysville, WA.
- United States Department of Agriculture, Soil Conservation Service. 1958. Soil survey of Island County, Washington. Natural Resources Conservation Service, Mt. Vernon, WA.
- Wagner, D. 1983. Preliminary study of alternative management strategies for Crockett Lake drainage basin. Report prepared for Island County Drainage District No. 6.
- Wahlin, G. 2000. Personal communication. Island County Noxious Weed Board, Coupeville, WA.



- Washington Department of Fish and Wildlife. 1998. Washington state salmonid stock inventory: bull trout/Dolly Varden. Olympia.
- Washington Department of Fish and Wildlife. 1999. 1999 Washington fishing guide. Olympia.
- Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes. 1994. 1992 Washington State salmon and steelhead stock inventory. Appendix 1: Puget Sound Stocks: North Puget Sound Volume, Olympia.
- Whitmore, C., C. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. *Trans. Am. Fish. Soc.* 89:17-26.
- Williams, W., R. Laramie, and J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1 – Puget Sound Region (WRIA). Washington Department of Fisheries, Olympia.
- Wingert, R. Craig and B. S. Miller. 1979. Distributional analysis of nearshore and demersal fish species groups and nearshore fish habitat associations in Puget Sound. Washington Department of Ecology, Olympia.
- Wirth, S. 1999. Spartina management plan for northern Puget Sound. Island County Noxious Weed Board, Coupeville, Washington.